

EXHIBIT 13

**THIS EXHIBIT HAS BEEN
REDACTED IN ITS ENTIRETY**

EXHIBIT 14

**THIS EXHIBIT HAS BEEN
REDACTED IN ITS ENTIRETY**

EXHIBIT 15

United States Patent [19]

Gendreau et al.

[11] Patent Number: **4,955,613**[45] Date of Patent: **Sep. 11, 1990**[54] **POLYBUTADIENE GOLF BALL PRODUCT**[75] Inventors: **Paul M. Gendreau, Swansea; Lauro C. Cadorniga, S. Dartmouth, both of Mass.**[73] Assignee: **Acushnet Company, New Bedford, Mass.**[21] Appl. No.: **319,640**[22] Filed: **Mar. 6, 1989**[51] Int. CL⁵ **A63B 37/00; A63B 37/06; A63B 37/12**[52] U.S. CL **273/218; 273/230; 273/235 R; 273/222; 260/998.14; 524/908; 525/193; 525/236**[58] Field of Search **525/193, 236; 524/908; 273/218, 220, 230, 222, 228, 227, 255 R; 260/998.14**[56] **References Cited****U.S. PATENT DOCUMENTS**

4,076,255	2/1978	Moore et al.	524/523
4,683,257	7/1987	Kakiuchi et al.	525/193
4,715,607	12/1987	Llort et al.	524/908
4,770,422	9/1988	Isaac	524/908

Primary Examiner—Allan M. Lieberman*Attorney, Agent, or Firm*—Lucas & Just[57] **ABSTRACT**

The golf ball product is made from two polybutadienes, each having a Mooney viscosity of below about 50 and a cis-1,4 content of greater than about 40%. One polybutadiene is nickel- or cobalt-catalyzed, while the other is lanthanide-catalyzed. The golf ball product includes a mix of the two polybutadienes, a metal salt of an unsaturated carboxylic acid and a free radical initiator.

10 Claims, No Drawings

4,955,613

1

POLYBUTADIENE GOLF BALL PRODUCT

This invention relates to golf balls and, more particularly, to an improved golf ball product made from a mix of two polybutadienes, each having a Mooney viscosity of no greater than about 50 (50 ML1+4(100° C.)).

Golf balls are made in three configurations: one-piece, two-piece and wound. A one-piece golf ball is a solid, homogeneous mass of rubber-like material, while a two-piece golf ball has a solid rubber core around which a cover has been molded. Wound golf balls are made by winding elastic thread about a center to produce a wound core. A cover is then molded about the wound core. The center is either a solid rubber mass or a liquid-filled envelope.

The term "golf ball product" as used herein means a unitary, one-piece golf ball, the core or cover of a two-piece golf ball, or the solid center or cover of a wound golf ball.

The United States Golf Association (USGA) promulgates rules for the game of golf which include specifications for the golf ball itself. Compliance with USGA rules is not obligatory and, indeed, some companies actually allege that they sell "hot" balls that violate USGA rules. Any major manufacturer of golf balls could easily make a "hot" ball which violates the USGA rules; however, all respectable manufacturers adhere to the USGA rules religiously since violation of a rule can result in the ball being banned from all USGA play. There are three performance tests for golf balls imposed by the USGA, one relating to velocity, another relating to golf ball symmetry, and the third relating to overall distance.

The velocity requirement, commonly referred to as the maximum initial velocity, specifies that the golf ball may not exceed a velocity of 250 feet (76.2 m) per second when measured on apparatus approved by the USGA. There is a 2% tolerance on the velocity, i.e. the highest permissible velocity is 255 feet (77.72 m) per second. Most manufacturers include a safety factor and make their average maximum velocities at some lesser value, such as in the 250-253 ft. (76.2-77.11 m) per second range, to minimize the risk of being declared "illegal."

U.S. Pat. No. 4,683,257, issued July 28, 1987, teaches a blend of two polybutadienes for use in a core of a two-piece golf ball where one of the polybutadienes has a Mooney viscosity of 70 to 100 (ML 1+4(100° C.)).

Applicants have now discovered a golf ball product made from a mix of two polybutadienes, each having a Mooney viscosity of no greater than about 50 (50 ML 1+4(100° C.)). A golf ball made in accordance with the present invention has been shown to have an improvement in initial velocity of about 1 foot (0.32 m) per second over a golf ball made with either one of the polybutadienes alone or with one of the polybutadienes and natural I5 rubber.

The golf ball product of the present invention has been found to be especially useful as a core of a two-piece golf ball.

The Mooney viscosity values used in the specification and claims were made in accordance with ASTM D1646-74 wherein the test parameters were L 1+4(100° C.). "L" indicates the use of the large rotor ("S" would indicate the small rotor), "1" is the time in minutes that the specimen was permitted to warm in the machine before starting the motor, "4" is the time in minutes

2

after starting the motor at which the reading is taken, and "100° C." is the temperature of the test.

A golf ball product made in accordance with the present invention comprises a mix of two polybutadienes, each said polybutadiene having a Mooney viscosity of below about 50; a metal salt of an unsaturated carboxylic acid; and a free radical initiator. Inorganic fillers may be added to adjust the weight or color of the golf ball product.

Each of the two polybutadienes has a cis-1,4 content greater than about 40% and, more preferably, greater than or equal to about 90%. Preferably, each of the two polybutadienes has a Mooney viscosity between about 35 to 50 and, more preferably, between about 40 to 45. Preferably, one of the polybutadienes has been prepared by polymerizing butadiene monomers with a nickel- or cobalt-containing catalyst while the other polybutadiene has been polymerized from butadiene monomers in the presence of a lanthanide-containing catalyst.

Nickel-containing catalysts used to prepare polybutadiene from butadiene monomers are, for example, one-component catalysts such as nickel on diatomaceous earth, two-component catalysts such as Raney nickel/titanium tetrachloride, and three-component catalysts such as nickel compound/organometal/trifluoroborate etherate. Examples of the nickel compounds include reduced nickel on carrier, Raney nickel, nickel oxides, nickel carboxylate, and organic nickel complex salts. Examples of the organometals include trialkyl aluminums such as triethyl aluminum, tri-n-propyl aluminum, triisobutyl aluminum, and tri-n-hexyl aluminum; alkyl lithiums such as n-butyl lithium, sec-butyl lithium, tert-butyl lithium, and 1,4-butane dilithium; dialkyl zincs such as diethyl zinc and dibutyl zinc; and the like. Polymerization of butadiene in the presence of these catalysts is generally carried out by continuously charging a reactor with butadiene monomer along with a solvent such as aliphatic, aromatic and cycloaliphatic hydrocarbon solvents, and a catalyst such as nickel octanoate and triethyl aluminum and controlling the reaction temperature in the range of 5° to 60° C. and the reaction pressure in the range from one to several atmospheres, namely from atmospheric pressure to about 70 atmospheres, such that a product having a predetermined Mooney viscosity may be obtained.

Examples of the cobalt-containing catalysts include elemental cobalt and cobalt compounds such as Raney cobalt, cobalt chloride, cobalt bromide, cobalt iodide, cobalt oxide, cobalt sulfate, cobalt carbonate, cobalt phosphate, cobalt phthalate, cobalt carbonyl, cobalt acetylacetonate, cobalt diethyldithiocarbamate, cobalt anilinium nitrite, cobalt dinitrosyl chloride, etc. In particular, combinations of these cobalt compounds with a dialkyl aluminum monochloride (e.g. diethyl aluminum monochloride and diisobutyl aluminum monochloride), a trialkyl aluminum (e.g. triethyl aluminum, tri-n-propyl aluminum, triisobutyl aluminum, and tri-n-hexyl aluminum), and aluminum chloride or with an alkyl aluminum sesquichloride (e.g. ethyl aluminum sesquichloride) and aluminum chloride are preferred catalysts for use in the preparation of polymers of cis-1,4 bond type. The process of preparing polybutadienes using the cobalt-containing catalysts is similar to that used with the nickel-containing catalysts.

A lanthanide-containing catalyst comprises a lanthanide rare earth element compound (hereinafter simply referred to as a lanthanide compound), an organoaluminum compound, a Lewis base and, optionally, a Lewis

4,955,613

3

acid. The lanthanide compounds include halides, carboxylates, alcoholates, thioalcoholates, and amides of metals having atomic numbers of 57 to 71, with neodymium being the preferred lanthanide compound. The organoaluminum compounds used herein may be those having the general formula $AlR^1R^2R^3$ wherein R^1 , R^2 and R^3 are independently selected from hydrogen and hydrocarbon residues having 1 to 8 carbon atoms, and R^1 , R^2 and R^3 may be the same or different.

The Lewis bases serve to convert the lanthanide compounds into complexes. Acetylacetone, ketone alcohols and the like may be used for this purpose.

The Lewis acids used include aluminum halides of the general formula: $AlX_nR_{(3-n)}$ wherein X is a halogen, R is a hydrocarbon residue (for example, hydrocarbon residues having 1 to about 20 carbon atoms such as alkyl, aryl, and aralkyl radicals), and n is equal to 1, 1.5, 2 or 3, and other metal halides such as silicon tetrachloride, tin tetrachloride, and titanium tetrachloride.

When butadiene is polymerized in the presence of the lanthanide-containing catalyst, the molar ratio of butadiene to lanthanide compound preferably ranges from 5×10^2 to 5×10^6 , especially from 10^3 to 10^5 , and the molar ratio of $AlR^1R^2R^3$ to lanthanide compound preferably ranges from 5 to 500, especially from 10 to 300. The preferred proportion of Lewis base to lanthanide compound is at least 0.5, and especially ranges from 1 to 20 in molar ratio. When a Lewis acid is used, the preferred proportion of halide in the Lewis acid to lanthanide compound ranges from 1 to 10, especially from 1.5 to 5 in molar ratio.

In the polymerization of butadiene, the lanthanide-containing catalysts may be used as solution in a suitable solvent such as n-hexane, cyclohexane, n-heptane, toluene, xylene, benzene, etc., or carried on suitable carriers such as silica, magnesia and magnesium chloride.

Polymerization of butadiene may be carried out in a solvent such as n-hexane, cyclohexane, n-heptane, toluene, xylene, benzene, etc., or bulk polymerization without a solvent may also be employed. The polymerization temperature typically ranges from -30°C . to 150°C . and, preferably, from 10°C . to 80°C . The polymerization pressure may vary depending on other conditions.

The term "lanthanide-catalyzed polybutadiene" as used in the specification and claims means a polybutadiene made from butadiene monomers polymerized with a lanthanide-containing catalyst. The term "group VIII-catalyzed polybutadiene" means a polybutadiene made from butadiene monomers polymerized with a nickel- or cobalt-containing catalyst. The term "nickel-catalyzed polybutadiene" means a polybutadiene made from butadiene monomers polymerized with a nickel-containing catalyst. The term "cobalt-catalyzed polybutadiene" means a polybutadiene made from butadiene monomers polymerized with a cobalt-containing catalyst.

A golf ball product made in accordance with the present invention comprises about 15 to about 85 parts by weight per 100 parts of rubber (phr) of a group VIII-catalyzed polybutadiene having a Mooney viscosity of no greater than about 50 and about 85 to about 15 phr of a lanthanide-catalyzed polybutadiene having a Mooney viscosity of no greater than about 50. More preferred is to employ about 75 to about 25 phr of a group VIII-catalyzed polybutadiene having a Mooney viscosity of no greater than about 50 and about 25 to about 75 phr of a lanthanide-catalyzed polybutadiene having a

4

Mooney viscosity of no greater than about 50. Good results have been obtained with about 50 phr of a group VIII-catalyzed polybutadiene having a Mooney viscosity of no greater than about 50 and about 50 phr of a lanthanide-catalyzed polybutadiene having a Mooney viscosity of no greater than about 50.

The unsaturated carboxylic acid is an alpha, beta ethylenically unsaturated carboxylic acid having 3 to 8 carbon atoms such as methacrylic, acrylic, cinnamic and crotonic acid, of which acrylic and methacrylic are preferred. Suitable metal ions are sodium, potassium, magnesium, calcium, zinc, barium, aluminum, tin, zirconium, lithium and cadmium, of which sodium, zinc and magnesium are preferred. The metal ion is preferably introduced in the form of the salt of the carboxylic acid. The most preferred salts are zinc diacrylate and zinc dimethacrylate.

In the golf ball product made in accordance with the present invention about 25 to about 45 phr of a metal salt of an unsaturated carboxylic acid is used. More preferably, about 27 to about 35 phr of a metal salt of an unsaturated carboxylic acid is used. Good results have been obtained by using about 29 to about 33 phr of a metal salt of an unsaturated carboxylic acid.

The free radical initiator or catalyst is a peroxide. Suitable peroxides include 1,1-di(t-butylperoxy)-3,3,5-trimethyl cyclohexane; t-butylperbenzoate; and a-a bis(t-butylperoxy) diisopropylenebenzene. Preferably, a combination of a-a bis(t-butylperoxy) diisopropylenebenzene and 1,1-di(t-butylperoxy)-3,3,5-trimethyl cyclohexane is used. Use of a dual initiator system is taught in U.S. Pat. No. 4,692,497 issued Sept. 8, 1987. The teachings of the '497 patent are incorporated herein by reference.

The total amount of free radical initiator used is between about 0.2 to about 2.0 phr and, more preferably, about 0.5 to about 1.0 phr. Good results have been obtained with about 0.5 to about 0.75 phr of free radical initiator.

Typical inorganic fillers include zinc oxide, titanium oxide and barium sulfate and are used in an amount of about 5 to about 25 phr.

A golf ball product made in accordance with the present invention comprises about 15 to about 85 phr of a group VIII-catalyzed polybutadiene having a cis-1,4 content above about 40% and a Mooney viscosity of no greater than about 50; about 15 to about 85 phr of a lanthanide-catalyzed polybutadiene having a cis-1,4 content above about 40% and a Mooney viscosity of no greater than about 50; about 25 to about 45 phr of a metal salt of an unsaturated carboxylic acid; about 0.2 to about 2.0 phr of a peroxide catalyst; and about 5 to about 25 phr of an inorganic filler.

Preferably, the golf ball product made in accordance with the present invention comprises about 25 to about 75 phr of a group VIII-catalyzed polybutadiene having a cis-1,4 content above about 40% and a Mooney viscosity of no greater than about 50; about 25 to about 75 phr of a lanthanide-catalyzed polybutadiene having a cis-1,4 content above about 40% and a Mooney viscosity of no greater than about 50; about 27 to 35 phr of a metal salt of an alpha, beta ethylenically unsaturated carboxylic acid having 3 to 8 carbon atoms; a peroxide catalyst; about 0.5 to about 1.0 phr by weight of a peroxide catalyst; and about 5 to about 25 phr of an organic filler.

Most preferred is a golf ball product comprising about 50 phr of a group VIII-catalyzed polybutadiene

4,955,613

5

having a cis-1,4 content of 90% or above and a Mooney viscosity of no greater than about 50; about 50 phr of a lanthanide-catalyzed polybutadiene having a cis-1,4 content of 90% or above and a Mooney viscosity of no greater than about 50; about 29 to about 33 phr of a metal salt of an unsaturated carboxylic acid; about 0.5 to about 0.75 phr of a peroxide catalyst; and about 5 to about 25 phr of an inorganic filler.

In order to form a golf ball product in accordance with the present invention, the two polybutadienes, the metal salt of a carboxylic acid and the inorganic filler are mixed together. When these components are initially mixed together, the temperature of the mixture rises to a temperature at which the polybutadienes and the metal carboxylate are readily admixed, suitably about 200° F. to 350° F. (93.3° C. to 176.7° C.). The mixing is continued at this elevated temperature until a good dispersion is achieved, which is generally about 3 to 30 minutes. The temperature of the mixture is then reduced to below the lower of the maximum stable temperatures of the free radical initiators to be used. The initiators are then added to the mixture, and the mixture is mixed while being held below the maximum stable temperature of the lower stable temperature of the free radical initiator for about 3 to 15 minutes. The mass is then suitably milled into slabs or extruded into rods from which pieces are cut slightly larger and heavier than the desired golf ball product to be formed. These pieces are placed in a golf ball product mold, such as a ball cup mold or a ball core mold, and cured at elevated temperature under pressure. A temperature of about 280° F. to 340° F. (137.8° C. to 171.1° C.) for a period of about 12 to 30 minutes has been found to be suitable. The pressure is not critical as long as it is sufficient to prevent the mold from opening during heating and curing.

These and other aspects of the present invention may be more fully understood with reference to the following examples.

EXAMPLE 1

This example illustrates making a golf ball product in accordance with the present invention. A total of five golf ball cores were made, two controls and three in accordance with the present invention. The compositions as well as the properties of the cores are illustrated in Table I below:

Component	Control (phr)		Present Invention (phr)		
	1	2	1	2	3
Group VIII-catalyzed polybutadiene	0	96	15	85	25
Lanthanide-catalyzed polybutadiene	100	0	85	15	75
Rubber	0	4	0	0	0
Metal salt of unsaturated carbox. acid	28	28	28	28	28
Processing aid	1.5	1.5	1.5	1.5	1.5
Inorganic fillers	28	28	28	28	28
Peroxide	0.53	0.53	0.53	0.53	0.53
Physical Properties					
PGA	80	75	87	82	80
Compression					

6

TABLE I-continued

Component	Control (phr)		Present Invention (phr)		
	1	2	1	2	3
Core weight (grams)	35.2	34.9	35.4	35.4	35.2
Initial velocity (ft./sec.)	251.1	250.7	252.1	251.9	251.2

The group VIII-catalyzed polybutadiene was Enichem 42 obtained from Enichem Co. Enichem 42 is a nickel-catalyzed polybutadiene having a Mooney viscosity of about 42.

The lanthanide-catalyzed polybutadiene was Shell 1220 obtained from Shell Co. and had a Mooney viscosity of about 45.

The rubber was conventional Standard Malaysia Rubber, natural rubber, a polymer of isoprene.

The metal salt of an unsaturated carboxylic acid was zinc diacrylate which is readily obtainable on the open market.

The processing aid was SR-350 obtained from Elastochem. SR-350 is trimethylol propane trimethacrylate.

The inorganic fillers were limestone, zinc oxide and barium sulfate. With respect to the amount of each component used, 5 phr of limestone, 14 phr of zinc oxide and 5 phr of barium sulfate were employed in each formulation.

The peroxide catalyst was a combination of 0.1 phr of Vulcup R and 0.43 phr of Varox 231XL. Vulcup R is a-a bis(t-butylperoxy) diisopropylenebenzene and Varox 231XL is 1,1-di(t-butylperoxy)-3,3,5-trimethyl cyclohexane.

These cores were made by mixing all components except the peroxide catalysts together for about 7 minutes in a Banbury mixer until good dispersion between the rubber components was achieved. The temperature during mixing rose to about 250° F. (122° C.). The temperature of the mix was then reduced to below the maximum stable temperature of both peroxide catalysts and then the catalysts were mixed in while the temperature of the mix was held below the maximum stabilization temperature of the catalysts. This mix was then made into pieces slightly larger than cores and the pieces were placed in conventional golf ball core molds for about 15 minutes at 325° F. (163° C.). The cores were then demolded and allowed to incubate at 72-75° F. (22-24° C.) for 24 hours. The core mold had an internal diameter of about 1.5 inches. The cores were then tested for physical properties after the incubation period.

The velocities obtained were comparable to those obtained in the standard USGA test. The PGA compression rating was obtained using a commercial PGA Compression Tester. Both of these measurement techniques are standard throughout the golf ball industry and are well-known to those of skill in the art of golf ball manufacturing.

EXAMPLE 2

Cores from Example 1, namely Present Invention 2 and Present Invention 3, had conventional Surlyn covers molded therearound and were tested for initial velocity along with a conventional golf ball, a Pinnacle manufactured by Acushnet Company. The Pinnacle is a two-piece golf ball having a solid core with a Surlyn

4,955,613

7

cover. The results of these tests are illustrated in Table II below:

TABLE II

Golf Ball	Initial Velocity
Pinnacle	251.7
Present Invention 2	252.57
Present Invention 3	252.59

It will be understood that each and every numerical value which appears in the claims herein is modified by the term "about" if the modifying term "about" does not appear in front of such numerical value.

It will be understood that the claims are intended to cover all changes and modifications of the preferred embodiments of the invention herein chosen for the purpose of illustration which do not constitute a departure from the spirit and scope of the invention.

What is claimed is:

1. A golf ball product comprising a mix of two polybutadienes, said mix comprising about 85 to about 15 phr of a nickel- or cobalt-catalyzed polybutadiene having a cis-1,4 content above about 40% and a Mooney viscosity of no greater than about 50 and about 15 to about 85 phr of a lanthanide-catalyzed polybutadiene having a cis-1,4 content above about 40% and a Mooney viscosity of no greater than about 50; a metal salt of an unsaturated carboxylic acid; and a free radical initiator.

2. A golf ball product comprising about 15 to about 85 phr of a nickel- or cobalt-catalyzed polybutadiene having a cis-1,4 content above about 40% and a Mooney viscosity of no greater than about 50; about 15 to about 85 phr of a lanthanide-catalyzed polybutadiene having a cis-1,4 content above about 40% and a Mooney viscosity of no greater than about 50; about 25 to about 45 phr of a metal salt of an unsaturated carboxylic acid; about 0.2 to about 2.0 phr of a peroxide catalyst; and about 5 to about 25 phr of an inorganic filler.

3. The golf ball product of claim 2 wherein said metal salt of an unsaturated carboxylic acid is selected from the group consisting of zinc diacrylate and zinc dimethacrylate.

8

4. The golf ball product of claim 2 wherein said peroxide catalyst is selected from the group consisting of 1,1-di(t-butylperoxy)-3,3,5-trimethyl cyclohexane; t-butylperbenzoate; and a-a bis (t-butylperoxy) diisopropylenebenzene.

5. The golf ball product of claim 2 wherein said peroxide catalyst is a combination of a-a bis(t-butylperoxy) diisopropylenebenzene and 1,1-di(t-butylperoxy)-3,3,5-trimethyl cyclohexane.

6. The golf ball product of claim 2 wherein said inorganic filler is selected from the group consisting of zinc oxide, titanium oxide and barium sulfate.

7. A golf ball core comprising:

(a) about 15 to about 85 phr of a nickel- or cobalt-catalyzed polybutadiene having a cis-1,4 content above about 40% and a Mooney viscosity of no greater than about 50;

(b) about 85 to about 15 phr of a lanthanide-catalyzed polybutadiene having a cis-1,4 content above about 40% and a Mooney viscosity of no greater than about 50;

(c) about 25 to about 45 phr of a metal salt of an unsaturated carboxylic acid; and

(d) a peroxide catalyst.

8. A golf ball core comprising:

(a) a mix of two polybutadienes, said mix consisting of about 85 to about 15 phr of a nickel- or cobalt-catalyzed polybutadiene having a cis-1,4 content above about 40% and a Mooney viscosity of no greater than about 50; and about 15 to about 85 phr of a lanthanide-catalyzed polybutadiene having a cis-1,4 content above about 40% and a Mooney viscosity of no greater than about 50;

(b) a metal salt of an alpha, beta ethylenically unsaturated carboxylic acid having 3 to 8 carbon atoms; and

(c) a peroxide catalyst.

9. The golf ball core of claim 7 wherein said metal salt is present in an amount of between about 25 to about 45 phr and said peroxide catalyst is present in an amount of between about 0.2 to about 2.0 phr.

10. The golf ball core of claim 9 further comprising about 5 to about 25 phr of an inorganic filler.

* * * * *

45

50

55

60

65

EXHIBIT 16



US005508350A

United States Patent [19][11] **Patent Number:** **5,508,350****Cadorniga et al.**: [45] **Date of Patent:** **Apr. 16, 1996**[54] **RUBBER COMPOSITION FOR GOLF BALL CORE AND GOLF BALL COMPRISING SAID CORE**[58] **Field of Search** 525/193, 274,
525/301; 524/399; 273/230[75] **Inventors:** **Lauro C. Cadorniga, Piedmont;**
Wayne R. Bradley, Seneca, both of
S.C.[56] **References Cited****U.S. PATENT DOCUMENTS**

4,561,657	12/1985	Tominaga et al.	273/218
4,688,801	8/1987	Reiter	273/218
4,838,556	6/1989	Sullivan	273/220
4,844,471	7/1989	Terence et al.	273/220
5,306,760	4/1994	Sullivan	524/399

[73] **Assignee:** **Dunlop Slazenger Corporation,**
Westminster, S.C.**OTHER PUBLICATIONS**[21] **Appl. No.:** **480,549****Concise Chem. & Tech Dic.** -1975 pp. 115 & 469.[22] **Filed:** **Jun. 7, 1995****Primary Examiner**—Carman J. Seccoro, Jr.
Attorney, Agent, or Firm—Lorusso & Loud**Related U.S. Application Data**[57] **ABSTRACT**[63] **Continuation of Ser. No. 153,803, Nov. 16, 1993, abandoned.**

Golf balls exhibiting an improved coefficient of restitution are obtained by including zinc palmeatate in the core formulation.

[51] **Int. Cl.⁶** **C08L 9/00; C08K 5/09;**
C08C 19/28; A63B 37/06[52] **U.S. Cl.** **525/193; 525/274; 525/301;**
524/399; 524/908; 273/230**18 Claims, No Drawings**

5,508,350

1

RUBBER COMPOSITION FOR GOLF BALL CORE AND GOLF BALL COMPRISING SAID CORE

This is a continuation of application(s) Ser. No. 08/153, 803 filed on Nov. 16, 1993, now abandoned which designated the U.S.

BACKGROUND OF THE INVENTION

This invention relates to golf balls, and more particularly, to a golf ball made of an improved rubber composition.

Conventional golf balls are made by molding a cover about a core (typically 1½" diameter core). The core is either a solid core, solid mass of material, or a wound core, elastic thread wound about the center. The center may be either a solid mass of material or a liquid filled cavity which is frozen prior to winding. Golf balls with solid cores are generally referred to as "two piece" golf balls while golf balls with wound cores are generally referred to as "three piece" golf balls. One piece golf balls are made from a homogeneous mass of material.

Rubber compositions now used as cores for two piece golf balls are formulated to possess high hardness and high compressive strengths. With such a formulation, the resiliency to optimize flight distance performance can be achieved. "Click" and "feel" are other qualities sought from a golf ball. "Click" is the sound made by a golf club head when it hits the ball. "Feel" is the overall sensation transmitted to the golfer after hitting the ball.

The polybutadiene elastomer commonly used for the rubber component of a core is crosslinked by a large amount of a zinc salt of acrylic or methacrylic acid, in order to increase hardness without decreasing resilience. Golf ball compounds crosslinked by acrylic acid zinc salts have generally exhibited superior characteristics in terms of resilience but tend to be less durable. Ball forming compounds crosslinked by methacrylic acid zinc salts produce a ball of superior durability but at the expense of resilience.

To date, golf ball manufacturers have added fatty acids to the golf ball to obtain the desired resiliency and compressive strengths. For example, Tominaga et al, U.S. Pat. No. 4,561,657, teaches that an improved golf ball can be made from a rubber composition containing zinc acrylate coated with a fatty acid such as stearic acid whereby the golf ball exhibits proper hardness, good impact resilience and good sound and feel when hit. Another characteristic of this type of rubber composition is that it creates good roll workability and dispersability of rubber additives.

It is desirable, however, to obtain a golf ball with a softer feel, and desirable click with excellent flight and distance performances while maintaining resilience and getting a designed reduction of hardness and compressive strengths.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a rubber composition formulation for use as a core in a two piece golf ball or as the composition for a one piece ball.

It is another object of the present invention to provide such a composition for golf balls to reduce hardness and compressive strengths yet maintain resilience.

A further object of the present invention is to provide such a composition so that golf balls produced have a softer feel and desirable click with excellent flight and distance performances.

2

These and other objects of the present invention are achieved with a formulation for golf balls in which zinc palmeate is added to a polymer composition formulation either by in situ or by dry blend method. Preferably, the additive comprises 5-15% by weight on the total zinc salt of the polymer composition formulation. The formulation of the present invention produces a core for a two piece golf ball or a one piece golf ball with a designed reduction in hardness and compressive strengths while maintaining resilience and imparting softer feel and good playability to the golfer.

DETAILED DESCRIPTION OF THE INVENTION

At the outset, the present invention is described in its broadest overall aspects with a more detailed description following. The composition of the present invention for producing a core for a golf ball is a blend of a polymer, a metal salt of an unsaturated carboxylic acid, a free radical initiator and an additive of palmitic acid. The composition may optionally include fillers, and modifiers, as necessary to fulfill requirements determined by those skilled in the art.

The golf ball according to the present invention is produced from a polymer that mainly includes high-cis-polybutadiene rubber. High-cis-polybutadiene rubber is produced with the use of various kinds of catalysts (for example nickel-containing catalysts, neodymium-containing catalysts, titanium containing catalysts, cobalt-containing catalysts and the like) and it is different to some extent in its properties depending upon the kind of catalyst which is utilized. Other polymers in addition to the above described high-cis-polybutadiene rubber may be added or substituted.

The preferred high-cis-polybutadiene rubber is neodymium catalyzed, having 97% or higher content of cis 1-4 and Mooney viscosity ranges of 35-60. A suitable polybutadiene polymer of this type is available under the product name Europrene Neo Cis from Enichem Elastomers Ltd, Charleston Road, Hardley, Hythe, Southampton SO4 6YY U.K. Another suitable polybutadiene polymer is sold by Miles Polysar and manufactured by Bayer AG, Postfach 100140, D4047 Dormagen Germany which is a subsidiary of Miles under the product name Buna CB. For use in the present invention, the preferred polybutadiene rubber will mix equal parts of the two above mentioned products, 50/50, based upon 100 parts by weight of all polymers.

The metal salt of an unsaturated carboxylic acid is used to crosslink the polymer. Suitable carboxylic acids include methacrylic, acrylic, dimethacrylic and diacrylic acids. Suitable metal ions include sodium, potassium, magnesium, cerium, zinc and cadmium, with zinc being preferred. The most preferred metal salts of the unsaturated carboxylic acids are therefore acrylate zinc salt, methacrylate zinc salt, diacrylate zinc salt and dimethacrylate zinc salt. The metal salt will be added in amounts ranging from 15 to 35 parts per hundred of the polymer formulation.

For the present invention, palmitic acid is introduced by an in situ method or zinc palmeate (produced from palmitic acid and zinc oxide) is introduced by dry blend method to the polymer composition formulation. Specifically, 5% to 15% by weight of palmitic acid is introduced in the reaction vessel to process the zinc salt. More preferably, the composition includes 10-15% by weight of palmitic acid on total zinc salt. The zinc palmeate, produced as described below, promotes a more reactive salt when compounded, especially to make cores for a two piece golf ball, than the current

5,508,350

3

method of using zinc stearate as an additive. The more reactive resultant zinc salt of a fatty acid produces higher compressive strengths thereby also producing higher resilience on molded core/golf balls. A suitable zinc salt with zinc palmeate is sold under the product name ZDA-J by Rockland React-Rite, Inc., 327 Industrial Drive, Rockmart, GA 30153.

The free radical initiator included in the core composition can be any known polymerization initiator which decomposes during the cure cycle. The amount of the selected initiator present is dictated only by the requirements of catalytic activity as a polymerization initiator. Suitable initiators for use in the present invention include peroxides, persulfates, azo compounds, hydrazines and the like. Peroxides such as dicumyl peroxide, nbutyl 4,4-bis (butylperoxide) valerate, 1,1-bis-(t-butylperoxy)-3,3,5-trimethylcyclohexane, di-t-butylperoxide and 3,5-di-(t-butylperoxy)-2,5 dimethylhexane and the like are readily commercially available and conveniently used, generally in amounts of from about 1.0 to about 5.0 and preferably in amounts of from about 1.0 to about 3.0 parts by weight based on 100 parts elastomer and most preferably 2.5 parts by weight of 40% active curative based upon 100 parts polymer. The preferred peroxide used in the present invention is 1,1-bis-(t-butyl-peroxy)-3,3,5-trimethylcyclohexane.

In the present invention, zinc oxide is used as an activator, as well as optionally used as a filler, and its role in the reaction of the present invention will be described below. Zinc oxide will be present in the formulation of the present invention in an amount from about 5 to about 30 parts by weight based upon 100 parts elastomer, and preferably 15-22 parts by weight based upon 100 parts elastomer.

The core compositions of the present invention may additionally include any other suitable and compatible modifying ingredients including, but not limited to, other fillers, metal oxides, and diisocyanates.

As fillers, any known and conventional filler material, or mixtures thereof, may be used. Such fillers should be in finely divided form, as for example, of a size generally less than about 30 mesh and preferably less than about 100 mesh U.S. standard screen size. Suitable fillers include silica, silicates, zinc oxide, carbon black, cork, titania, cotton flock, cellulose flock, leather fiber, plastic and/or leather flour, asbestos, glass fibers, metal carbonates, barium sulfate in its natural or synthetic form, talc, graphite fibers and the like. Particularly useful as a filler is the oxide or carbonate of the cation present in the selected metal carboxylate component.

The amount of filler included in the core composition is primarily dictated by weight restrictions and is preferably from about 15 to about 30 parts by weight based on 100 parts elastomer.

To produce the core composition of the present invention, zinc palmeate is formed initially. One method to produce zinc palmeate is an in situ process. This process involves addition of acrylic acid, palmeate acid and zinc oxide to a reactor vessel with a hydrocarbon solvent. The end products of above method are zinc diacrylate and zinc palmeate, which are produced together in the reactor.

An alternate method of producing zinc palmeate involves combining palmitic acid and ZnO, without acrylic acid present. The resulting product is zinc palmeate. This can be accomplished by reactor process or hot roll mill process, and these methods are known to those skilled in the relevant art.

The first method produces zinc diacrylate coated and/or intimately blended with zinc palmeate and the blend is

4

added to the rubber composition as one component. With the second method, zinc palmeate, manufactured by itself, is added as an individual component to the rubber composition. If this method is employed, then zinc diacrylate is also added as an individual component of the rubber composition.

Compounding of rubber stock is accomplished by an internal mixer, such as a Banbury mixer or an open mill process. The preferred method of mixing is Banbury or internal mixer. Rubber and various components comprising the formulation are added in a sequence which allows for homogeneous mixing, that does not reach incipient polymerization temperatures for the batch. The mixing cycle is dependent upon time, temperature, type, and mixing volume of equipment.

After mixing, the batch is discharged onto a drop mill. The stock is sheeted from the drop mill and allowed to cool. The stock is then extruded into preforms of desired weight and dimensions. This is accomplished by use of continuous extruding equipment or batch extrusion equipment.

The preforms of the composition will be cured by heating the composition at elevated temperatures on the order of from about 275° F. to about 350° F., preferably from about 295° F. to about 325° F., with molding of the composition effected simultaneously with the curing thereof. The composition can be formed into a core structure by using any one of a number of suitable molding techniques, e.g., injection, compression or transfer molding procedures. When the composition is cured by the application of heat, the time required for curing will normally be of short duration, generally from about 10 to about 20 minutes, depending upon the particular curing agent used. Those of ordinary skill in the art relating to free radical curing agents for polymers are conversant with adjustments of cure times and temperatures required to effect optimum results with any free radical generating agent.

After molding, the core is removed from the mold and the surface thereof is preferably treated to facilitate adhesion thereof to the covering compositions. Surface treatment can be effected by any of the several techniques known in the art, such as corona discharge, ozone treatment, sand blasting and the like. Preferably, surface treatment is effected by grinding with an abrasive wheel during a centerless grinding operation which yields a round core of approximately 1.5 inches in diameter.

Spew, which is cured cored stock, is formed during molding when excess preform material flows into adjacent overflow areas around the cavity halves. This cured material is mechanically removed from the cores after the cores are removed from the moulds. The spew is loaded into grinding equipment. The resultant ground particles are passed through 30 mesh screens. The ground material is called regrind. This material is recycled and is used as a reinforcing filler to improve durability.

In a preferred embodiment of the present invention, the ground core spew, or "regrind", produced during this surface treatment, can be added to the formulation for a golf ball core, in amounts ranging from 3 to 10% by weight of compound formulation. The regrind will preferably have particle size less than 30 mesh.

The core is converted into a golf ball by providing at least one layer of covering composition thereon, ranging in thickness from about 0.050 to about 0.250 inch and preferably from about 0.060 to about 0.090 inch. The process to finish a golf ball with a cover is well known, and it is within the knowledge of those skilled in the art to finish a golf ball made with the core composition of the present invention.

5,508,350

5

Cores produced according to the present invention provide a golf ball having higher resilience and coefficients of restitution. More importantly for the golfer, the golf ball produced will have a desirable softer feel and click, with excellent flight and distance performances.

The following examples are to be considered as illustrative and not limiting.

Golf ball cores were made with the following compositions using conventional methods of mixing, extruding, surface finishing and molding to produce cores. Cores were

6

covered with ionomer blends using conventional methods to produce golf balls. Compositions 1-28 are listed below. Average physical properties of the finished products, that is cores and balls, are listed as averages of the compression and coefficient of restitution.

FORMULAS	1	2	3	4	5	6	7	8	9	10
<u>MATERIALS</u>	PHR	PHR	PHR	PHR	PHR	PHR	PHR	PHR	PHR	PHR
HI CIS	100	100	100	100	100	100	100	100	100	100
POLYBUTADIENE	—	—	—	—	—	—	—	—	—	—
BARYTES	20.0	20.0	20.0	20.0	20.0	20.0	19.75	19.75	19.75	19.75
ZNO	26.5	26.5	26.5	26.5	26.5	26.5	27.5	27.5	27.5	27.5
ZDA	—	4.68	—	—	2.34	—	—	4.85	—	—
ZN PALMEATATE ¹	—	—	—	4.68	—	2.34	—	—	—	4.85
ZN PALMEATATE ²	4.68	—	—	—	2.34	—	4.85	—	—	—
ZN STEARATE ¹	—	—	4.68	—	—	2.34	—	—	4.85	—
ZN STEARATE ²	—	—	—	—	—	—	—	—	—	—
REGRIND	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
PEROXIDE	—	—	—	—	—	—	—	—	—	—
<u>PHYSICAL PROPERTIES</u>										
AVG CORE COMPRESSION	68	72	66	66	70	66	77	83	73	74
AVG BALL COMPRESSION	89	93	88	90	92	88	101	107	101	101
AVG COEFFICIENT OF RESTITUTION	0.733	0.737	0.732	0.733	0.735	0.734	0.742	0.750	0.744	0.745
FORMULAS	11	12	13	14	15	16	17	18	19	20
<u>MATERIALS</u>	PHR	PHR	PHR	PHR	PHR	PHR	PHR	PHR	PHR	PHR
HI CIS	100	100	100	100	100	100	100	100	100	100
POLYBUTADIENE	—	—	—	—	—	—	—	—	18.3	18.3
BARYTES	19.75	19.75	19.0	19.0	19.0	19.0	19.0	19.0	5.0	5.0
ZNO	27.5	27.5	31.0	31.0	31.0	31.0	31.0	31.0	22.5	22.5
ZDA	2.42	—	—	5.47	—	—	2.73	—	—	4.0
ZN PALMEATATE ¹	—	2.42	—	—	—	5.47	—	2.73	—	—
ZN PALMEATATE ²	2.42	—	5.47	—	—	—	2.73	—	4.0	—
ZN STEARATE ¹	—	2.42	—	—	5.47	—	—	2.73	3.0	3.0
ZN STEARATE ²	—	—	—	—	—	—	—	—	6.75	6.75
REGRIND	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
PEROXIDE	—	—	—	—	—	—	—	—	—	—
<u>PHYSICAL PROPERTIES</u>										
AVG CORE COMPRESSION	76	70	88	93	82	83	88	81	62	60
AVG BALL COMPRESSION	103	99	110	114	107	106	109	106	95	95
AVG COEFFICIENT OF RESTITUTION	0.744	0.741	0.748	0.754	0.743	0.747	0.748	0.745	0.738	0.737
FORMULAS	21	22	23	24	25	26	27	28		
<u>MATERIALS</u>	PHR	PHR	PHR	PHR	PHR	PHR	PHR	PHR		
HI CIS	100	100	100	100	100	100	100	100		
POLYBUTADIENE	—	—	—	—	—	—	—	—		
BARYTES	18.3	18.3	—	—	—	—	—	—		
ZNO	5.0	5.0	20.0	20.0	19.75	19.75	19.0	19.0		
ZDA	21.7	21.7	26.5	26.5	27.5	27.5	31.0	31.0		
ZN PALMEATATE ¹	—	3.8	—	4.68	—	4.85	—	5.47		
ZN PALMEATATE ²	—	—	—	—	—	—	—	—		
ZN STEARATE ¹	3.8	—	4.68	—	4.85	—	5.47	—		
ZN STEARATE ²	3.0	3.0	—	—	—	—	—	—		
REGRIND	6.75	6.75	8.75	8.75	8.75	8.75	8.75	8.75		
PEROXIDE	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5		
<u>PHYSICAL PROPERTIES</u>										
AVG CORE COMPRESSION	58	58	84	87	87	90	97	102		

5,508,350

7

-continued

8

AVG BALL COMPRESSION	93	92	107	111	109	112	118	118
AVG COEFFICIENT OF RESTITUTION	0.737	0.738	0.744	0.746	0.742	0.745	0.751	0.754

¹In situ²Post added

With respect to formulas 1-6, all having zinc diacrylate (ZDA) levels of 26.5 phr, it was found that formula 2 which uses zinc palmeate in situ when manufacturing ZDA has higher physical properties than the other formulas with the same ZDA level. The improvement in coefficient of restitution is apparent.

Formulas 7 through 12 have the same 27.5 ZDA phr level. Formula 8 which uses zinc palmeate in situ produces a ball with higher physical properties and, again, the improvements in coefficient of restitution is apparent.

Formulas 13-18 all have a ZDA phr level of 31.0 with formula 14 which uses zinc palmeate in situ producing a ball with the best physical properties.

Formulas 19-20 having ZDA phr levels at 22.5 and formulas 21 and 22 with levels of 21.7 use ZDA phr levels below normal usage. In these instances, however, the addition of regrind is shown to improve durability and compression, and adding 3 phr zinc stearate raises coefficient of restitution. The addition of barytes achieves desired core weight and reduces cost.

Formulas 23-24, with a ZDA phr level at 26.5 and the addition of regrind at 8.75 phr illustrates that the addition of regrind improves coefficient of restitution and raises core and ball compression.

Formulas 25-26 have a ZDA phr level of 27.5, and formulas 27 and 28 have levels of 31 phr. These formulas also include 8.75 phr of regrind, which illustrates that with

that addition, core compression and ball compression are raised without improving coefficient of restitution. Formula 26 has comparable ingredients as formula 8 except it also includes regrind but does not show improved properties. The same comparison is made with formula 28 and formula 14 but shows raised core compression and ball compression without improving coefficient of restitution.

In conclusion, it is noted that using 26.5 to 31 phr ZDA with zinc palmeate in situ improves coefficient of restitution. The addition of regrind at 26.5 phr level ZDA with zinc palmeate in situ also improves coefficient of restitution. The addition of regrind at ZDA phr level between 26.5-27.5 does not improve coefficient of restitution. Between 27.5-31 phr ZDA using zinc palmeate in situ, the addition of regrind increased ball compression and core compression. That formula having 27.5 phr ZDA results in coefficient of restitution being reduced, but at 31 phr ZDA the coefficient of restitution is constant. It is also seen that regrind usage improves durability at low levels of ZDA usage.

Additional formulas were developed using alternative polymer components, as follows. A golf ball was produced as described above. The following tables illustrate durability changes. The larger the number, the more durable the golf ball becomes.

FORMULAS	1	2	3	4	5	6	7	8	9	10
MATERIALS	PHR	PHR	PHR	PHR	PHR	PHR	PHR	PHR	PHR	PHR
NEO CIS 40	50	50	50	50	50	50	50	50	50	50
CB-23	50	50	50	50	50	50	50	50	50	50
BARYTES	—	—	—	—	—	—	—	—	—	—
ZNO	20.0	20.0	20.0	20.0	20.0	20.0	19.75	19.75	19.75	19.75
ZDA	26.5	26.5	26.5	26.5	26.5	26.5	27.5	27.5	27.5	27.5
ZN PALMEATE ¹	—	4.68	—	—	2.34	—	—	4.85	—	—
ZN PALMEATE ²	—	—	—	4.68	—	2.34	—	—	—	4.85
ZN STEARATE ¹	4.68	—	—	—	2.34	—	4.85	—	—	—
ZN STEARATE ²	—	—	4.68	—	—	2.34	—	—	4.85	—
REGRIND	—	—	—	—	—	—	—	—	—	—
PEROXIDE	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
PHYSICAL PROPERTIES										
AVG CORE WT	35.08	34.95	34.90	34.88	34.96	34.91	35.00	34.93	34.72	34.82
AVG BALL WT	45.55	45.54	45.35	45.34	45.48	45.35	45.56	45.56	45.31	45.35
AVG DURABILITY	114	125	84	119	101	110	119	146	119	124
FORMULAS	11	12	13	14	15	16	17	18	19	20
MATERIALS	PHR	PHR	PHR	PHR	PHR	PHR	PHR	PHR	PHR	PHR
NEO CIS 40	50	50	50	50	50	50	50	50	50	50
CB-23	50	50	50	50	50	50	50	50	50	50
BARYTES	—	—	—	—	—	—	—	—	18.3	18.3
ZNO	19.75	19.75	19.0	19.0	19.0	19.0	19.0	19.0	5.0	5.0
ZDA	27.5	27.5	31.0	31.0	31.0	31.0	31.0	31.0	22.5	22.5
ZN PALMEATE ¹	2.42	—	—	5.47	—	—	2.73	—	—	4.0
ZN PALMEATE ²	—	2.42	—	—	—	5.47	—	2.73	—	—
ZN STEARATE ¹	2.42	—	5.47	—	—	—	2.73	—	4.0	—
ZN STEARATE ²	—	2.42	—	—	5.47	—	—	2.73	3.0	3.0

5,508,350

9

-continued

10

REGRIND	—	—	—	—	—	—	—	—	6.75	6.75
PEROXIDE	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
PHYSICAL PROPERTIES										
AVG CORE WT	34.98	34.73	35.01	35.01	34.86	34.90	34.99	34.86	35.20	35.24
AVG BALL WT	45.55	45.32	45.68	45.68	45.44	45.48	45.65	45.46	45.24	45.21
AVG DURABILITY	109	98	106	108	116	129	133	111	145	163
FORMULAS	21	22	23	24	25	26	27	28		
MATERIALS	PHR	PHR	PHR	PHR	PHR	PHR	PHR	PHR	PHR	
NEO CIS 40	50	50	50	50	50	50	50	50	50	
CB-23	50	50	50	50	50	50	50	50	50	
BARYTES	18.3	18.3	—	—	—	—	—	—	—	
ZNO	5.0	5.0	20.0	20.0	19.75	19.75	19.0	19.0	19.0	
ZDA	21.7	21.7	26.5	26.5	27.5	27.5	31.0	31.0	31.0	
ZN PALMEATATE ¹	—	3.8	—	4.68	—	4.85	—	—	5.47	
ZN PALMEATATE ²	—	—	—	—	—	—	—	—	—	
ZN STEARATE ¹	3.8	—	4.68	—	4.85	—	5.47	—	—	
ZN STEARATE ²	3.0	3.0	—	—	—	—	—	—	—	
REGRIND	6.75	6.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	
PEROXIDE	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	
PHYSICAL PROPERTIES										
AVG CORE WT	35.30	35.20	35.48	35.48	35.38	35.43	35.49	35.56		
AVG BALL WT	45.16	45.17	45.54	45.47	45.53	45.42	45.67	45.68		
AVG DURABILITY	165	163	106	153	129	180	195	190		

¹In situ²Post added

Physical properties were tested as indicated herein. Average core compression is measured in 0.001 inch deflection given in PGA units. Average core weight is measured in grams. Average ball compression is the same measurement as with cores, except finished golf balls made with the various formulas are compressed. The average ball weight is measured in grams. Average coefficient of restitution indicates an average of ball velocity, measuring rebound velocity/forward velocity. Average durability means the number of hits before mechanical failure of a group of samples.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and there is no intention to exclude any equivalence thereof. Hence, it is recognized that various modifications are possible when within the scope of the present invention as claimed.

What is claimed is:

1. A golf ball comprising a cover and a molded single fatty acid core, said single fatty acid core comprising:

an elastomer selected from high-cis polybutadiene and mixtures of high-cis polybutadiene with other elastomers;

25-37 phr based upon 100 phr elastomer of a homogeneous blend of 85-95% by weight zinc diacrylate and 5-15% by weight zinc palmeate, formed from the reaction of palmitic acid, acrylic acid, and zinc oxide; and

1.0-5.0 parts by weight of a free radical initiator based upon 100 parts elastomer.

2. The golf ball of claim 1 wherein the core further comprises 3-20 phr by weight of zinc oxide.

3. The golf ball of claim 1 wherein the core further comprises 3-20 phr by weight of zinc oxide and one or more fillers.

4. The golf ball of claim 1 wherein the core comprises 1.0-3.0 parts by weight of a free radical initiator based upon 100 parts elastomer.

5. The golf ball of claim 4 wherein the core further comprises 3-20 phr by weight of zinc oxide.

6. The golf ball of claim 4 wherein the core further comprises 3-20 phr by weight of zinc oxide and one or more fillers.

7. The golf ball of claim 1 wherein the core further comprises ground core spew in the amount of 3 to 10% by weight of the core formulation.

8. An improved core composition for a golf ball, said composition comprising

an elastomer selected from high-cis polybutadiene and mixtures of high-cis polybutadiene with other elastomers;

25-37 phr based upon 100 phr elastomer of a homogeneous blend of 85-95% by weight zinc diacrylate and 5-15% by weight zinc palmeate, formed from the reaction of palmitic acid, acrylic acid, and zinc oxide; and

1.0-5.0 parts by weight of a free radical initiator based upon 100 parts elastomer.

9. The core composition of claim 8 further comprising 3-20 phr by weight of zinc oxide.

10. The core composition of claim 8 further comprising 3-20 phr by weight of zinc oxide and one or more fillers.

11. The core composition of claim 8 wherein the core comprises:

1.0-3.0 parts by weight of a free radical initiator based upon 100 parts elastomer.

12. The core composition of claim 11 further comprising 3-20 phr by weight of zinc oxide.

13. The core composition of claim 11 further comprising 3-20 phr by weight of zinc oxide and one or more fillers.

14. The composition of claim 8 wherein the core further comprises ground core spew in the amount of 3 to 10% by weight of the composition.

5,508,350

11

15. A method for making an improved core for a high performance two piece golf ball comprising:

- (a) providing a base elastomer selected from high-cis polybutadiene and mixtures of high-cis polybutadiene with other elastomers;
- (b) providing 25-37 phr based upon 100 phr elastomer of a homogeneous blend of 85-95% by weight zinc diacrylate and 5-15% by weight zinc palmeatate, formed from the reaction of palmitic acid acrylic acid, and zinc oxide; and
- (c) blending the compositions of step (a) and (b) with 1.0 to 5.0 parts by weight of a free radical initiator based upon 100 parts elastomer;

12

(d) molding the composition of step (c) to form a golf ball core.

16. The method of claim 15 further comprising blending 3-20 phr by weight of zinc oxide into the blend of step (c).

17. The method of claim 15 further comprising blending 3-20 phr by weight of zinc oxide and one or more fillers into the blend of step (c).

18. The method of claim 15 further comprising the step of adding 3-10% by weight ground core spew with particle size less than 30 mesh to the composition mixing in step (c) prior to the molding step.

* * * * *

EXHIBIT 17



US006486261B1

(12) **United States Patent**
Wu et al.

(10) Patent No.: **US 6,486,261 B1**
(45) Date of Patent: **Nov. 26, 2002**

- (54) **THIN-LAYER-COVERED GOLF BALL WITH IMPROVED VELOCITY**
- (75) Inventors: Shenshen Wu, North Dartmouth, MA (US); Edmund A. Hebert, Fairhaven, MA (US); Laurent Bissonnette, Portsmouth, RI (US); David A. Bulpitt, Boston, MA (US); Murali Rajagopalan, South Dartmouth, MA (US); Peter Voorheis, Fall River, MA (US); Mark N. Wrigley, New Bedford, MA (US)
- (73) Assignee: Acushnet Company, Fairhaven, MA (US)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 45 days.

(21) Appl. No.: 09/721,740
(22) Filed: Nov. 27, 2000

Related U.S. Application Data

- (63) Continuation-in-part of application No. 09/461,736, filed on Dec. 16, 1999, and a continuation-in-part of application No. 09/311,591, filed on May 14, 1999, now Pat. No. 6,210,294, and a continuation-in-part of application No. 09/274,015, filed on Mar. 22, 1999.
- (60) Provisional application No. 60/113,949, filed on Dec. 24, 1998.
- (51) Int. Cl.⁷ A63B 37/12; A63B 37/06
- (52) U.S. Cl. 525/332.6; 525/332.5; 525/274; 473/374; 473/376; 473/377; 473/378
- (58) Field of Search 525/274, 332.6, 525/332.5; 473/374, 376, 377, 378

(56) References Cited

U.S. PATENT DOCUMENTS

3,147,324 A	9/1964	Ward	264/254
3,239,228 A	3/1966	Crompton	273/218
3,572,721 A	3/1971	Harrison et al.	372/218
3,572,722 A	3/1971	Harrison et al.	273/218
3,804,421 A	4/1974	Alex et al.	273/218
3,808,077 A	4/1974	Rieser et al.	156/102
3,989,568 A	11/1976	Isaac	156/182
3,992,014 A	11/1976	Retford	273/218
4,062,825 A	12/1977	Watabe et al.	260/37 N
4,123,061 A	10/1978	Dusbiber	273/220
4,274,637 A	6/1981	Molitor	273/235 R
4,310,582 A	1/1982	Stumpe, Jr.	428/182

4,650,193 A	3/1987	Molitor et al.	273/228
4,692,497 A	9/1987	Gendreau et al.	525/263
4,931,376 A	6/1990	Ikematsu et al.	526/164
4,971,329 A	11/1990	Llort et al.	273/218
5,017,636 A	5/1991	Hattori et al.	524/300
5,025,059 A	6/1991	Mouri et al.	524/495
5,131,662 A	7/1992	Pollitt	273/230
5,141,233 A	8/1992	Yuki et al.	273/218
5,252,652 A	10/1993	Egashira et al.	524/392
5,421,580 A	6/1995	Sugimoto et al.	273/227
5,461,109 A	10/1995	Blair et al.	524/839
5,496,496 A	3/1996	Kajita et al.	252/182.24
5,585,440 A	12/1996	Yamada et al.	525/193
5,587,420 A	12/1996	Takizawa et al.	524/572
5,697,856 A	12/1997	Moriyama et al.	473/374
5,744,549 A	4/1998	Lutz	525/129
5,779,561 A	7/1998	Sullivan et al.	473/373
5,803,831 A	9/1998	Sullivan et al.	473/374
5,816,944 A	10/1998	Asakura et al.	473/372
5,827,134 A	10/1998	Sullivan et al.	473/372
5,856,388 A	1/1999	Harris et al.	524/320
5,859,153 A	1/1999	Kirk et al.	525/481
5,861,465 A	1/1999	Hamada et al.	525/332.6
5,885,173 A	3/1999	Keller	473/385
5,919,101 A	7/1999	Yokota et al.	473/374
5,929,171 A	7/1999	Sano et al.	525/261
6,012,997 A	1/2000	Mason	473/594
6,190,268 B1 *	2/2001	Dewanjee	
6,290,611 B1 *	9/2001	Rajagopalan	
6,309,313 B1 *	10/2001	Peter	
6,315,684 B1 *	11/2001	Binette	

FOREIGN PATENT DOCUMENTS

AU	A-16547/97	2/1997
AU	A-16548/97	2/1997
EP	0 577 058 A1	1/1994
EP	0 903 357 A1	3/1999
GB	1 168 609	10/1969
GB	1 209 032	10/1970
GB	2 321 021 A	3/1997

* cited by examiner

Primary Examiner—David J. Buttner

(74) Attorney, Agent, or Firm—Swidler Berlin Shereff Friedman, LLP

(57) ABSTRACT

A golf ball comprising a center comprising a polybutadiene having a molecular weight of greater than 200,000 and a resilience index of at least about 40; and a cover layer comprising a polyurethane composition formed from a pre-polymer having no greater than 7.5 percent by weight unreacted isocyanate groups.

50 Claims, 1 Drawing Sheet

U.S. Patent

Nov. 26, 2002

US 6,486,261 B1

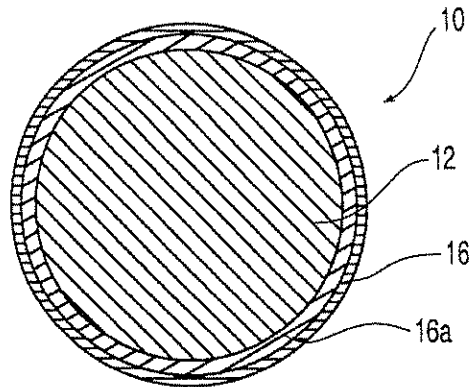


Fig. 1

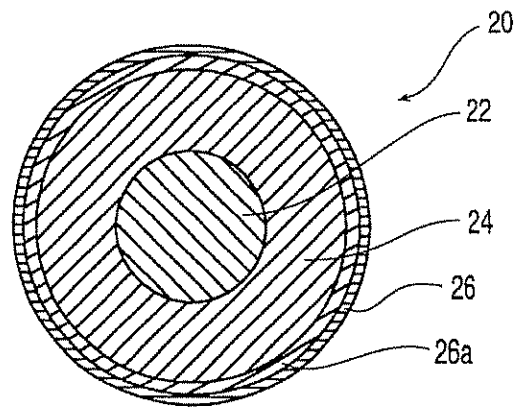


Fig. 2

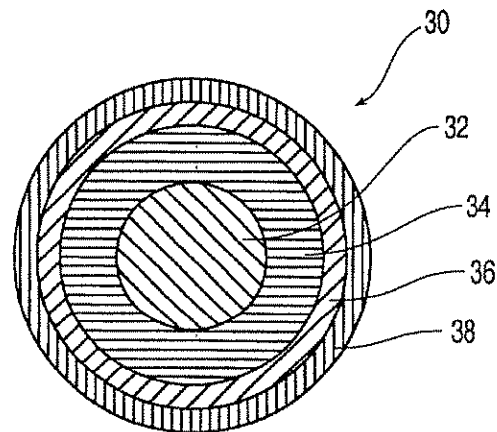


Fig. 3

US 6,486,261 B1

1

THIN-LAYER-COVERED GOLF BALL WITH IMPROVED VELOCITY

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of co-pending U.S. patent application Ser. No. 09/461,736, filed Dec. 16, 1999, which claims the benefit of provisional U.S. patent application No. 60/113,949, filed Dec. 24, 1998, a continuation-in-part of U.S. patent application Ser. No. 09/311,591, filed May 14, 1999, now U.S. Pat. No. 6,210,294 and also a continuation-in-part of co-pending U.S. patent application Ser. No. 09/274,015, filed Mar. 22, 1999.

FIELD OF THE INVENTION

The invention relates generally to golf balls, and more specifically, to golf balls with covers formed of a polymer blend comprising a polyurethane composition and cores formed of a polybutadiene composition. The polyurethane composition comprises a prepolymer of a polyisocyanate and a polyol, and a diamine curing agent. The polybutadiene composition comprises a butadiene polymer with a resilience index greater than about 40 and a molecular weight greater than about 200,000. The golf balls of the present invention have been found to provide improved velocity.

BACKGROUND OF THE INVENTION

Conventional golf balls can be divided into several general classes: (a) solid golf balls having one or more layers, and (b) wound golf balls. Solid golf balls include one-piece balls, which are easy to construct and relatively inexpensive, but have poor playing characteristics and are thus generally limited for use as range balls. Two-piece balls are constructed with a generally solid core and a cover and are generally the most popular with recreational golfers because they are very durable and provide maximum distance. Balls having a two-piece construction are commonly formed of a polymeric core encased by a cover. Typically, the core is formed from polybutadiene that is chemically crosslinked with zinc diacrylate and/or other similar crosslinking agents. These balls are generally easy to manufacture, but are regarded as having limited playing characteristics. Solid golf balls also include multi-layer golf balls that are comprised of a solid core of one or more layers and/or a cover of one or more layers. These balls are regarded as having an extended range of playing characteristics.

Wound golf balls are generally preferred by many players due to their high spin and soft "feel" characteristics. Wound golfballs typically include a solid, hollow, or fluid-filled center, surrounded by a tensioned elastomeric material and a cover. Wound balls generally are more difficult and expensive to manufacture than solid two-piece balls.

A variety of golf balls have been designed by manufacturers to provide a wide range of playing characteristics, such as compression, velocity, "feel," and spin. These characteristics can be optimized for various playing abilities. One of the most common components that manufacturers have addresses for optimizing and/or altering the playing characteristics of golf balls, is the polymer components present in modern golf ball construction, in particular, golf ball centers and/or core. In addition to ionomers, one of the most common polymers employed is polybutadiene and, more specifically, polybutadiene having a high cis-isomer concentration.

The use of a polybutadiene having a high cis-concentration results in a very resilient and rigid golf ball,

2

especially when coupled with a hard cover material. These highly resilient golf balls have a relatively hard "feel" when struck by a club. Soft "feel" golf balls constructed with a high cis-polybutadiene have low resilience. In an effort to provide improved golf balls, various other polybutadiene formulations have been prepared, as discussed below.

U.S. Pat. No. 3,239,228 discloses a solid golf ball having a core molded of polybutadiene rubber with a high sulfur content, and a cover. The polybutadiene content of the core is stereo-controlled to the configuration 25-100 percent cis- and 0-65 percent trans-1,4-polybutadiene, with any remainder having a vinyl configuration of polybutadiene. A preferred embodiment of the polybutadiene golf ball core contains 35 percent cis-, 52 percent trans-, and 13 percent vinyl-polybutadiene. The level of trans- and vinyl-content are disclosed to be unimportant to the overall playing characteristics of the polymer blend.

British Patent No. 1,168,609 discloses a molding composition from which improved golf ball cores can be molded and which contains cis-polybutadiene as a basic polymer component. The core polymer component typically includes at least 60 percent cis-polybutadiene, with the remainder being either the trans- or vinyl-forms of polybutadiene. In a preferred embodiment, the core polybutadiene component contains 90 percent cis-configuration, with the remaining 10 percent being either the trans- or vinyl-configurations of 1,4-polybutadiene.

U.S. Pat. Nos. 3,572,721 and 3,572,722 disclose a solid, one- or two-piece golf ball, with the two-piece ball having a core and a cover. The cover material can include any one of a number of materials, or blends thereof, known to those of ordinary skill in the art, including trans-polybutadiene which may be present in an amount from at least 90 percent, with the remainder being the cis- and/or vinyl configuration.

British Patent No. 1,209,032 discloses a two- or three-piece golf ball having a core and a cover. The core or cover material can be any material capable of being crosslinked. In particular, the material can be a polymer or a copolymer of butadiene or isoprene. Preferably, the polymer component is polybutadiene having a cis content of greater than 50 percent by weight.

U.S. Pat. No. 3,992,014 discloses a one-piece, solid golf ball. The golf ball material is typically polybutadiene, with a stereo-configuration selected to be at least 60 percent cis-polybutadiene, with the remaining 40 percent being the trans-polybutadiene and/or 1,2-polybutadiene (vinyl) isomers.

U.S. Pat. No. 4,692,497 discloses a golf ball and material thereof formed by curing a diene polymer including polybutadiene and a metal salt of an alpha, beta ethylenically unsaturated acid using at least two free radical initiators.

U.S. Pat. No. 4,931,376 discloses a process for producing butadiene polymers for use in various applications, including golf ball cover materials. One embodiment of the invention employs a blended polymeric resin material, including at least percent by weight of a trans-polybutadiene polymer as a golf ball cover on a two-piece ball. In a preferred embodiment, the golf ball cover material contains a blend including 30 to 90 percent by weight of a trans-polybutadiene polymer.

U.S. Pat. No. 4,971,329 discloses a solid golf ball made from a polybutadiene admixture of cis-1,4 polybutadiene and 1,2 polybutadiene, a metal salt of an unsaturated carboxylic acid, an inorganic filler, and a free radical initiator. The admixture has about 99.5 percent to about 95 percent by weight of cis-1,4 polybutadiene and about 0.5 percent to about 5 percent by weight of 1,2 polybutadiene.

US 6,486,261 B1

3

U.S. Pat. No. 5,252,652 discloses a one-piece or multi-layered golf ball core with improved flying performance from a rubber composition comprising a base rubber, preferably 1,4-polybutadiene with a cis-content of at least 40 mole percent, an unsaturated carboxylic acid metal salt, an organic peroxide, and an organic sulfur compound and/or a metal salt thereof. The organic sulfur compound and/or a metal salt is typically present in an amount from about 0.05 to 2 parts per hundred by weight and the organic peroxide is typically present in an amount from about 0.5 to 3 parts per hundred by weight of the total polymer component.

European Patent No. 0 577 058 discloses a golf ball containing a core and a cover that is formed as two separate layers. The inner layer of the cover is molded over the core and is formed from ionomer resin. The outer layer of the cover is molded over the inner layer and is formed from a blend of natural or synthetic balata and a crosslinkable elastomer, such as polybutadiene. In one embodiment of the outer layer of the cover, the elastomer is 1,4-polybutadiene having a cis-structure of at least 40 percent, with the remaining 60 percent being the trans-isomer. A preferred embodiment contains a cis-structure of at least 90 percent and more preferably, a cis-structure of at least 95 percent.

U.S. Pat. No. 5,421,580 discloses a wound golf ball having a liquid center contained in a center bag, a rubber thread layer formed on the liquid center, and a cover over the wound layer and liquid center. The cover material can include any one of a number of materials, or blends thereof, known to those of ordinary skill in the art, including trans-polybutadiene and/or 1,2-polybutadiene (vinyl), such that the cover has a JIS-C hardness of 70-85; preferred trans-percentages are not disclosed.

U.S. Pat. No. 5,697,856 discloses a solid golf ball having a core and a cover wherein the core is produced by vulcanizing a base rubber composition containing a butadiene rubber having, a cis-polybutadiene structure content of not less than 90 percent before vulcanization. The amount of trans-polybutadiene structure present after vulcanization is 10 to 30 percent, as amounts over 30 percent are alleged to detrimentally result in cores that are too soft with deteriorated resilience performance, and to cause a decrease in golf ball performance. The core includes a vulcanizing agent, a filler, an organic peroxide, and an organosulfur compound.

British Patent No. 2,321,021 discloses a solid golf ball having a core and a cover formed on the core and having a two-layered cover construction having an inner cover layer and an outer cover layer. The outer cover layer is comprised of a rubber composite that contains 0.05 to 5 parts by weight of an organic sulfide compound. The core rubber composition comprises a base rubber, preferably 1,4-polybutadiene having a cis-content of at least 40 percent by weight, a crosslinking agent, a co-crosslinking agent, an organic sulfide, and a filler. The crosslinking agent is typically an organic peroxide present in an amount from 0.3 to 5.0 parts by weight and the co-crosslinking agent is typically a metal salt of an unsaturated fatty acid present in an amount from 10 to 40 parts by weight. The organic sulfide compound is typically present from 0.05 to 5 parts by weight.

U.S. Pat. No. 5,816,944 discloses a solid golf ball having a core and a cover wherein the core has a JIS-C hardness of 50 to 80 and the cover has a Shore-D hardness of 50 to 60. The core material includes vulcanized rubber, such as cis-polybutadiene, with a crosslinker, an organic peroxide, an organosulfur compound and/or a metal-containing organosulfur compound, and a filler.

Additionally, conventional polymers that have a high percentage of the trans-polybutadiene conformation, such as

4

DIENE 35NF, from Firestone Corp., that has 40 percent cis-isomer and 50 percent trans-polybutadiene isomer, and mixtures of high-cis- and high-trans-polybutadiene isomers, such as CARIFLEX BR1220, from Shell Corporation, and FUREN 88, from Asahi Chemical Co., respectively, typically do not yield high resilience values and therefore are not desirable.

In addition to changing center or core ingredients to affect golf ball performance characteristics, a number of patents have issued that are directed towards modifying the properties of layers and covers used in forming a variety of golf balls, such as wound balls, conventional solid balls, multi-layer balls having dual cover layers, dual core layers, and/or balls having a mantle layer disposed between the cover and the core. The most common polymers used by manufacturers in golf ball layers and covers have been ionomers, such as SURLYN, commercially available from E.I. DuPont de Nemours and Co., of Wilmington, Del. Recently, however, manufacturers have investigated the use of alternative polymers, such as polyurethane. For example, U.S. Pat. No. 3,147,324 is directed to a method of making a golf ball having a polyurethane cover.

Polyurethanes have been recognized as useful materials for golf ball covers since about 1960. Polyurethane is the product of a reaction between a polyurethane prepolymer and a curing agent. The polyurethane prepolymer is a product formed by a reaction between a polyol and a diisocyanate. The curing agents used previously are typically diamines or glycols. A catalyst is often employed to promote the reaction between the curing agent and the polyurethane prepolymer.

Since 1960, various companies have investigated the usefulness of polyurethane as a golf ball cover material. U.S. Pat. No. 4,123,061 teaches a golf ball made from a polyurethane prepolymer of polyether and a curing agent, such as a trifunctional polyol, a tetrafunctional polyol, or a diamine. U.S. Pat. No. 5,334,673 discloses the use of two categories of polyurethane available on the market, i.e., thermoset and thermoplastic polyurethanes, for forming golf ball covers and, in particular, thermoset polyurethane covered golf balls made from a composition of polyurethane prepolymer and a slow-reacting amine curing agent, and/or a difunctional glycol. The first commercially successful polyurethane covered golf ball was the Titleist® Professional ball, first released in 1993.

Unlike SURLYN® or ionomer-covered golf balls, polyurethane golf ball covers can be formulated to possess the soft "feel" of balata covered golf balls. However, golf ball covers made from polyurethane have not, to date, fully matched SURLYN®-covered golf balls with respect to resilience or the rebound that is a function of the initial velocity of a golf ball after impact with a golf club.

U.S. Pat. No. 3,989,568 discloses a three-component system employing either one or two polyurethane prepolymers and one or two polyols or fast-reacting diamine curing agents. The reactants chosen for the system must have different rates of reactions within two or more competing reactions.

U.S. Pat. No. 4,123,061 discloses a golf ball made from a polyurethane prepolymer of polyether and a curing agent, such as a trifunctional polyol, a tetrafunctional polyol, or a fast-reacting diamine curing agent.

U.S. Pat. No. 5,334,673 discloses a golf ball cover made from a composition of a polyurethane prepolymer and a slow-reacting polyamine curing agent and/or a difunctional glycol. Resultant golf balls are found to have improved shear

US 6,486,261 B1

5

resistance and cut resistance compared to covers made from balata or SURLYN®.

U.S. Pat. No. 5,692,974 discloses methods of using cationic ionomers in golf ball cover compositions. Additionally, the patent relates to golf balls having covers and cores incorporating urethane ionomers. Improved resiliency and initial velocity are achieved by the addition of an alkylating agent such as t-butyl-chloride which induces ionic interactions in the polyurethane to produce cationic type ionomers.

International patent application WO 98/37929 discloses a composition for golf ball covers that comprises a blend of a diisocyanate/polyol prepolymer and a curing agent comprising a blend of a slow-reacting diamine and a fast-reacting diamine. Improved "feel", playability, and durability characteristics are exhibited.

Conventional polyurethane elastomers are known to have lower resiliency than SURLYN® and other ionomer resins. It has now been discovered that the use of a polyurethane composition, according to the present invention, in forming golf ball cores, intermediate and mantle layers, and/or covers, can raise the velocity of a golf ball prepared with the composition: (1) closer to the velocities observed with SURLYN®-covered golf balls; and (2) higher than the velocities exhibited using alternative urethane compositions. Additionally, it is desired to combine polyurethane cover compositions with polybutadiene core materials, especially those having resilience indices greater than about 40. Cores formed of materials such as these have been found to provide exceptional resiliency characteristics without a loss in performance characteristics (i.e., decreased compression).

It is thus desired to prepare golf balls having lower compression, i.e., a softer ball, while having the same or higher resilience than conventional balls. It is alternatively desired to obtain the same or lower compression while achieving greater resilience.

SUMMARY OF THE INVENTION

The present invention is directed to a golf ball comprising a center comprising a polybutadiene having a molecular weight of greater than 200,000 and a resilience index of at least about 40; and a cover layer comprising a polyurethane composition formed from a prepolymer having no greater than 7.5 percent by weight unreacted isocyanate groups. Preferably, the resilience index is greater than about 50.

The prepolymer may include an isocyanate, at least one polyol, and at least one curing agent. Preferably, the isocyanate includes 4,4'-diphenylmethane diisocyanate, polymeric 4,4'-diphenylmethane diisocyanate, carbodimide-modified liquid 4,4'-diphenylmethane diisocyanate, 4,4'-dicyclohexylmethane diisocyanate, p-phenylene diisocyanate, toluene diisocyanate, isophorondiisocyanate, p-methylxylene diisocyanate, m-methylxylene diisocyanate, o-methylxylene diisocyanate, or a mixture thereof. The at least one polyol may include polyether polyols, hydroxy-terminated polybutadiene, polyester polyols, polycaprolactone polyols, polycarbonate polyols, and mixtures thereof. The curing agent may include a polyamine curing agent, a polyol curing agent, or a mixture thereof. It is preferred, however, that the curing agent is a polyamine curing agent.

If the polyamine is selected as the curing agent, the polyamine curing agent may include 3,5-dimethylthio-2,4-toluenediamine and isomers thereof; 3,5-diethyltoluene-2,4-diamine and isomers thereof; 4,4'-bis-(sec-butylamino)-diphenylmethane; 1,4-bis-(sec-butylamino)-benzene, 4,4'-methylene-bis-(2-chloroaniline); 4,4'-methylene-bis-(3-chloro-2,6-diethylaniline); trimethylene glycol-di-p-

6

aminobenzoate; polytetramethyleneoxide-di-p-aminobenzoate; N,N'-dialkylidiamino diphenyl methane; p,p'-methylene dianiline; phenylenediamine; 4,4'-methylene-bis-(2-chloroaniline); 4,4'-methylene-bis-(2,6-diethylaniline); 4,4'-diamino-3,3'-diethyl-5,5'-dimethyl diphenylmethane; 2,2',3,3'-tetrachloro diamino diphenylmethane; 4,4'-methylene-bis-(3-chloro-2,6-diethylaniline); and mixtures thereof.

In one embodiment, however, the curing agent is a polyol curing agent. If the curing agent is a polyol, preferably, the polyol curing agent includes ethylene glycol; diethylene glycol; polyethylene glycol; propylene glycol; polypropylene glycol; lower molecular weight polytetramethylene ether glycol; 1,3-bis(2-hydroxyethoxy)benzene; 1,3-bis-[2-(2-hydroxyethoxy)ethoxy]benzene; 1,3-bis-[2-(2-hydroxyethoxy)ethoxy]ethoxy]benzene; 1,4-butanediol; 1,5-pentanediol; 1,6-hexanediol; resorcinol-di-(β-hydroxyethyl)ether; hydroquinone-di-(β-hydroxyethyl) ether; trimethylol propane, and mixtures thereof.

In another embodiment, the prepolymer has between about 2.5 percent and about 7.5 percent by weight unreacted isocyanate groups. The cover layer preferably has a thickness of less than about 0.05 inches. Further, the center should have a Mooney viscosity of between about 40 and about 80 and, preferably, between about 45 and about 60. In a preferred embodiment, the polybutadiene has a vinyl-polybutadiene isomer content of less than about 2 percent by weight and the polybutadiene has a cis-isomer content of at least about 95 percent by weight.

The golf ball center outer diameter is preferably of no less than about 1.55 inches and, additionally, the center further includes a material formed from a conversion reaction of polybutadiene having a first amount of trans-polybutadiene, a free radical source, and at least one cis-to-trans catalyst. Preferably, the reaction occurs at a temperature sufficient to form a polybutadiene reaction product having an second amount of trans-polybutadiene greater than the first amount of trans-polybutadiene. The cis-to-trans catalyst may include at least one of an organosulfur component, an inorganic sulfur compound, an aromatic organometallic compound, a metal-organosulfur compound, tellurium, selenium, elemental sulfur, a polymeric sulfur, or an aromatic organic compound. The organosulfur component may include at least one of 4,4'-diphenyl disulfide, 4,4'-ditolyl disulfide, or 2,2'-benzamido diphenyl disulfide. Preferably, the cis-to-trans catalyst is present in an amount from about 0.1 to 10 parts per hundred of polybutadiene.

In another embodiment, the golf ball further includes an intermediate layer juxtaposed between the center and the cover layer, wherein the intermediate layer comprises a material formed from a conversion reaction of polybutadiene having a first amount of trans-polybutadiene, a free radical source, and a cis-to-trans catalyst comprising at least one organosulfur component, wherein the intermediate layer has an outer diameter of no less than about 1.58 inches, and wherein the center has an outer diameter of less than about 1.55 inches. In yet another embodiment, the cover layer comprises an inner cover layer and an outer cover layer, the inner cover layer juxtaposed the center and the outer cover layer. Preferably, at least one of the inner and outer cover layer has a thickness of less than about 0.05 inches.

If present, the inner cover layer is formed from at least one material selected from the group comprising of an ionomer resin, a polyurethane, a polyetherester, a polyetheramide, a polyester, a dynamically vulcanized elastomer, a functionalized styrenebutadiene elastomer, a metallocene polymer,

US 6,486,261 B1

7

nylon, acrylonitrile butadiene-styrene copolymer or blends thereof. In still another embodiment, the inner cover has an outer diameter of at least about 1.55 inches and, preferably, between about 1.58 and about 1.64 inches. In an additional embodiment, the polyurethane is a thermoplastic or thermoset material.

The present invention is also directed to a golf ball comprising a center comprising a polybutadiene having a molecular weight of greater than 300,000 and a resilience index of at least about 40; an outer core layer having an outer diameter of no less than about 1.51 inches; an inner cover layer surrounding the outer core layer; and an outer cover layer comprising of a polyurethane composition formed from a prepolymer having no greater than about 7.5 percent by weight unreacted isocyanate groups. Preferably, the resilience index is greater than about 50.

The prepolymer may include an isocyanate, at least one polyol, and at least one curing agent. Preferably, the isocyanate includes 4,4'-diphenylmethane diisocyanate, polymeric 4,4'-diphenylmethane diisocyanate, carbodiimide-modified liquid 4,4'-diphenylmethane diisocyanate, 4,4'-dicyclohexylmethane diisocyanate, p-phenylene diisocyanate, toluene diisocyanate, isophoronediiisocyanate, p-methylxylene diisocyanate, m-methylxylene diisocyanate, o-methylxylene diisocyanate, or a mixture thereof. The at least one polyol may include polyether polyols, hydroxy-terminated polybutadiene, polyester polyols, polycaprolactone polyols, polycarbonate polyols, and mixtures thereof. The curing agent may include a polyamine curing agent, a polyol curing agent, or a mixture thereof. It is preferred, however, that the curing agent is a polyamine curing agent.

If the polyamine is selected as the curing agent, the polyamine curing agent may include 3,5-dimethylthio-2,4-toluenediamine and isomers thereof, 3,5-diethyltoluene-2,4-diamine and isomers thereof, 4,4'-bis-(sec-butylamino)-diphenylmethane; 1,4-bis-(sec-butylamino)-benzene, 4,4'-methylene-bis-(2-chloroaniline); 4,4'-methylene-bis-(3-chloro-2,6-diethylaniline); trimethylene glycol-di-p-aminobenzoate; polytetramethyleneoxide-di-p-aminobenzoate; N,N'-dialkyldiamino diphenyl methane; p,p'-methylene dianiline; phenylenediamine; 4,4'-methylene-bis-(2-chloroaniline); 4,4'-methylene-bis-(2,6-diethylaniline); 4,4'-diamino-3,3'-diethyl-5,5'-dimethyl diphenylmethane; 2,2',3,3'-tetrachloro diamino diphenylmethane; 4,4'-methylene-bis-(3-chloro-2,6-diethylaniline); and mixtures thereof.

In one embodiment, however, the curing agent is a polyol curing agent. If the curing agent is a polyol, preferably, the polyol curing agent includes ethylene glycol; diethylene glycol; polyethylene glycol; propylene glycol; polypropylene glycol; lower molecular weight polytetramethylene ether glycol; 1,3-bis(2-hydroxyethoxy)benzene; 1,3-bis-[2-(2-hydroxyethoxy)ethoxy]benzene; 1,3-bis-[2-[2-(2-hydroxyethoxy)ethoxy]ethoxy]benzene; 1,4-butanediol; 1,5-pentanediol; 1,6-hexanediol; resorcinol-di-(-hydroxyethyl)ether; hydroquinone-di-(-hydroxyethyl)ether; trimethylol propane, and mixtures thereof.

In another embodiment, the prepolymer has between about 2.5 percent and about 7.5 percent by weight unreacted isocyanate groups. At least one of the inner and outer cover layers preferably has a thickness of less than about 0.05 inches. Further, the center should have a Mooney viscosity of between about 40 and about 80. In a preferred embodiment, the polybutadiene has a vinyl-polybutadiene isomer content of less than about 2 percent by weight and the polybutadiene has a cis-isomer content of at least about 95 percent by weight.

8

The golf ball center outer diameter is preferably of no less than about 1.55 inches and, additionally, the center further includes a material formed from a conversion reaction of polybutadiene having a first amount of trans-polybutadiene, a free radical source, and at least one cis-to-trans catalyst. Preferably, the reaction occurs at a temperature sufficient to form a polybutadiene reaction product having an second amount of trans-polybutadiene greater than the first amount of trans-polybutadiene. The cis-to-trans catalyst may include at least one of an organosulfur compound, an inorganic sulfur compound, an aromatic organometallic compound, a metal-organosulfur compound, tellurium, selenium, elemental sulfur, a polymeric sulfur, or an aromatic organic compound. The organosulfur component may include at least one of 4,4'-diphenyl disulfide, 4,4'-ditolyl disulfide, or 2,2'-benzamido diphenyl disulfide. Preferably, the cis-to-trans catalyst is present in an amount from about 0.1 to 10 parts per hundred of polybutadiene.

In one embodiment, the inner cover layer includes an ionomer resin, a polyurethane, a polyetherester, a polyetheramide, a polyester, a dynamically vulcanized elastomer, a functionalized styrenebutadiene elastomer, a metallocene polymer nylon, acrylonitrile butadiene-styrene copolymer or blends thereof. The inner cover may have an outer diameter of at least about 1.55 inches and, preferably, between about 1.58 and about 1.64 inches. In an additional embodiment, the polyurethane is a thermoplastic or thermoset material.

The present invention is also directed to a golf ball comprising a center formed of a cis-polybutadiene having a molecular weight of greater than 300,000 and a resilience index of at least about 40; an outer core layer having an outer diameter of no less than about 1.51 inches; an inner cover layer surrounding the outer core layer, the inner cover layer comprising a polyurethane; and an outer cover layer comprising an ionomer or an elastomeric material.

The present invention is also directed to a golf ball comprising a center comprising a polybutadiene having a molecular weight of greater than 300,000 and a resilience index of at least about 40; an outer core layer having an outer diameter of no less than about 1.51 inches; an inner cover layer surrounding the outer core layer; and an outer cover layer; wherein the inner and outer cover layers are formed of a polyurethane composition.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of a two-piece golf ball having a cover and a core according to the invention;

FIG. 2 is a cross-section of a golf ball having an intermediate layer between a cover and a center according to the invention; and

FIG. 3 is a cross-section of a golf ball having more than one intermediate layer between a cover and a center according to the invention.

DEFINITIONS

The term "about," as used herein in connection with one or more numbers or numerical ranges, should be understood to refer to all such numbers, including all numbers in a range.

As used herein, "cis-to-trans catalyst" means any component or a combination thereof that will convert at least a portion of cis-polybutadiene isomer to trans-polybutadiene isomer at a given temperature. It should be understood that the combination of the cis-isomer, the trans-isomer, and any

US 6,486,261 B1

9

vinyl-isomer, measured at any given time, comprises 100 percent of the polybutadiene.

As used herein, the term "active ingredients" is defined as the specific components of a mixture or blend that are essential to the chemical reaction.

As used herein, substituted and unsubstituted "aryl" groups means a hydrocarbon ring bearing a system of conjugated double bonds, typically comprising $4n+2$ ring electrons, where n is an integer. Examples of aryl groups include, but are not limited to phenyl, naphthyl, anisyl, tolyl, xylenyl and the like. According to the present invention, aryl also includes heteroaryl groups, e.g., pyrimidine or thiophene. These aryl groups may also be substituted with any number of a variety of functional groups. In addition to the functional groups described herein in connection with carbocyclic groups, functional groups on the aryl groups can include hydroxy and metal salts thereof; mercapto and metal salts thereof; halogen; amino, nitro, cyano, and amido; carboxyl including esters, acids, and metal salts thereof; silyl; acrylates and metal salts thereof; sulfonyl or sulfonamide; and phosphates and phosphites; and a combination thereof.

As used herein, the term "Atti compression" is defined as the deflection of an object or material relative to the deflection of a calibrated spring, as measured with an Atti Compression Gauge, that is commercially available from Atti Engineering Corp. of Union City, N.J. Atti compression is typically used to measure the compression of a golf ball. When the Atti Gauge is used to measure cores having a diameter of less than 1.680 inches, it should be understood that a metallic or other suitable shim is used to make the measured object 1.680 inches in diameter. However, when referring to the compression of a core, it is preferred to use a compressive load measurement. The term "compressive load" is defined as the normalized load in pounds for a 10.8-percent diametrical deflection for a spherical object having a diameter of 1.58 inches.

As used herein, substituted and unsubstituted "carbocyclic" means cyclic carbon-containing compounds, including, but not limited to cyclopentyl, cyclohexyl, cycloheptyl, adamantyl, and the like. Such cyclic groups may also contain various substituents in which one or more hydrogen atoms has been replaced by a functional group. Such functional groups include those described above, and lower alkyl groups having from 1-28 carbon atoms. The cyclic groups of the invention may further comprise a heteroatom.

As used herein, the term "coefficient of restitution" for golf balls is defined as the ratio of the rebound velocity to the inbound velocity when balls are fired into a rigid plate. The inbound velocity is understood to be 125 ft/s.

As used herein, the term "dynamic stiffness" is defined as load divided by the deflection for a 1.4-mm spherical radius penetration probe oscillating at 1 Hz with an amplitude of 100 μ m. The probe dynamically penetrates the surface of a sample material. Material samples of spherical cores were prepared by sectioning out a 6-mm-thick layer along the equator of core to produce a disk 6 mm thick with one surface containing the geometric center of the core. By positioning the probe at any selected radial position on the disk, a dynamic stiffness measurement may be obtained. Accurate dynamic measurements may be made by keeping the material sample at a substantially uniform temperature. The dynamic stiffness was acquired using a Dynamic Mechanical Analyzer, Model DMA 2980 available from TA Instruments Corporation of New Castle, Del. The instrument setting for the DMA 2980 were 1-Hz frequency, 100 μ m

10

amplitude, 0.3-N static load, and auto strain of 105 percent. The 1.4-mm spherical radius probe is available from TA Instruments as a penetration kit accessory to the DMA 2980. The DMA 2980 is equipped with a temperature-controlled chamber that enables testing at a wide variety of ambient temperatures.

The method and instrument utilized for measuring "dynamic stiffness" may also be used to measure loss tangent (also commonly referred to as $\tan \delta$). Loss tangent is the ratio of loss modulus to storage modulus. Loss modulus is the portion of modulus which is out of phase with displacement and storage modulus is the portion of modulus which is in phase with displacement. The DMA 2980 automatically calculates and reports loss tangent.

As used herein, the terms "Group VIA component" or "Group VIA element" mean a component that includes a sulfur component, a selenium component, or a tellurium component, or a combination thereof.

As used herein, the term "sulfur component" means a component that is elemental sulfur, polymeric sulfur, or a combination thereof. It should be further understood that "elemental sulfur" refers to the ring structure of S_8 and that "polymeric sulfur" is a structure including at least one additional sulfur relative to the elemental sulfur.

As used herein, the term "fluid" includes a liquid, a paste, a gel, a gas, or any combination thereof.

As used herein, the term "molecular weight" is defined as the absolute weight average molecular weight. The molecular weight is determined by the following method: approximately 20 mg of polymer is dissolved in 10 mL of tetrahydrofuran ("THF"), which may take a few days at room temperature depending on the polymer's molecular weight and distribution. One liter of THF is filtered and degassed before being placed in a high-performance liquid chromatography ("HPLC") reservoir. The flow rate of the HPLC is set to 1 mL/min through a Viscogel column. This non-shedding, mixed bed, column model GMH_{HR}-H, which has an ID of 7.8 mm and 300 mm long is available from Viscotek Corp. of Houston, Tex. The THF flow rate is set to 1 mL/min for at least one hour before sample analysis is begun or until stable detector baselines are achieved. During this purging of the column and detector, the internal temperature of the Viscotek TDA Model 300 triple detector should be set to 40° C. This detector is also available from Viscotek Corp. The three detectors (i.e., Refractive Index, Differential Pressure, and Light Scattering) and the column should be brought to thermal equilibrium, and the detectors should be purged and zeroed, to prepare the system for calibration according to the instructions provided with this equipment. A 100- μ L aliquot of sample solution can then be injected into the equipment and the molecular weight of each sample can be calculated with the Viscotek's triple detector software. When the molecular weight of the polybutadiene material is measured, a dn/dc of 0.130 should always be used. It should be understood that this equipment and these methods provide the molecular weight numbers described and claimed herein, and that other equipment or methods will not necessarily provide equivalent values as used herein.

As used herein, the term "multilayer" means at least two layers and includes liquid center balls, wound balls, hollow-center balls, and balls with at least two intermediate layers and/or an inner or outer cover.

As used herein, the term "parts per hundred," also known as "phr," is defined as the number of parts by weight of a particular component present in a mixture, relative to 100

US 6,486,261 B1

11

parts by weight of the total polymer component. Mathematically, this can be expressed as the weight of an ingredient divided by the total weight of the polymer, multiplied by a factor of 100.

As used herein, the term "substantially free" means less than about 5 weight percent, preferably less than about 3 weight percent, more preferably less than about 1 weight percent, and most preferably less than about 0.01 weight percent.

As used herein the term "resilience index" is defined as the difference in loss tangent measured at 10 cpm and 1000 cpm divided by 990 (the frequency span) multiplied by 100,000 (for normalization and unit convenience). The loss tangent is measured using an RPA 2000 manufactured by Alpha Technologies of Akron, Ohio. The RPA 2000 is set to sweep from 2.5 to 1000 cpm at a temperature of 100° C. using an arc of 0.5 degrees. An average of six loss tangent measurements were acquired at each frequency and the average is used in calculation of the resilience index. The computation of resilience index is as follows:

$$\text{Resilience Index} = 100,000 \{ (\text{loss tangent @ 10 cpm}) - (\text{loss tangent @ 1000 cpm}) \} / 990$$

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. 1, a golf ball 10 of the present invention can include a core 12, a cover 16, and optional inner cover layer 16a surrounding the core 12. Referring to FIG. 2, a golf ball 20 of the present invention can include a center 22, a cover 26, an inner cover layer 26a, and at least one intermediate layer 24 disposed between the cover and the center. Each of the cover and center may also include more than one layer; i.e., the golf ball can be a conventional three-piece wound ball, a two-piece ball, a ball having a multi-layer core or an intermediate layer or layers, etc. Thus, referring to FIG. 3, a golf ball 30 of the present invention can include a center 32, a cover 38, and intermediate layers 34 and 36 disposed between the cover and the center. Although FIG. 3 shows only two intermediate layers, it will be appreciated that any number or type of intermediate layers may be used, as desired.

The present invention relates to two piece golf balls having a core and a cover, or multilayer golf balls having a solid, hollow, or fluid-filled center, a cover, and at least one intermediate layer disposed concentrically adjacent to the center. At least one of the center or optional intermediate layer includes a reaction product that includes a cis-to-trans catalyst, a resilient polymer component having polybutadiene, a free radical source, and optionally, a crosslinking agent, a filler, or both. Preferably, the reaction product has a first dynamic stiffness measured at -50° C. that is less than about 130 percent of a second dynamic stiffness measured at 0° C. More preferably, the first dynamic stiffness is less than about 125 percent of the second dynamic stiffness. Most preferably, the first dynamic stiffness is less than about 110 percent of the second dynamic stiffness.

The invention also includes a method to convert the cis-isomer of the polybutadiene resilient polymer component to the trans-isomer during a molding cycle and to form a golf ball. Various combinations of polymers, cis-to-trans catalysts, fillers, crosslinkers, and a source of free radicals, may be used. To obtain a higher resilience and lower compression center or intermediate layer, a high-molecular weight polybutadiene with a cis-isomer content preferably greater than about 90 percent is converted to increase the

12

percentage of trans-isomer content at any point in the golf ball or portion thereof, preferably to increase the percentage throughout substantially all of the golf ball or portion thereof, during the molding cycle. More preferably, the cis-polybutadiene isomer is present in an amount of greater than about 95 percent of the total polybutadiene content. Without wishing to be bound by any particular theory, it is believed that a low amount of 1,2-polybutadiene isomer ("vinyl-polybutadiene") is desired in the initial polybutadiene, and the reaction product. Typically, the vinyl polybutadiene isomer content is less than about 7 percent. Preferably, the vinyl polybutadiene isomer content is less than about 4 percent. More preferably, the vinyl polybutadiene isomer content is less than about 2 percent. Without wishing to be bound by any particular theory, it is also believed that the resulting mobility of the combined cis- and trans-polybutadiene backbone is responsible for the lower modulus and higher resilience of the reaction product and golf balls including the same.

To produce a polymer reaction product that exhibits the higher resilience and lower modulus (low compression) properties that are desirable and beneficial to golf ball playing characteristics, high-molecular-weight cis-1,4-polybutadiene, preferably may be converted to the trans-isomer during the molding cycle. The polybutadiene material typically has a molecular weight of greater than about 200,000. Preferably, the polybutadiene molecular weight is greater than about 250,000, more preferably between about 300,000 and 500,000. Without wishing to be bound by any particular theory, it is believed that the cis-to-trans catalyst component, in conjunction with the free radical source, acts to convert a percentage of the polybutadiene polymer component from the cis- to the trans-conformation. The cis-to-trans conversion requires the presence of a cis-to-trans catalyst, such as an organosulfur or metal-containing organosulfur compound, a substituted or unsubstituted aromatic organic compound that does not contain sulfur or metal, an inorganic sulfide compound, an aromatic organometallic compound, or mixtures thereof. The cis-to-trans catalyst component may include one or more of the other cis-to-trans catalysts described herein.

In one embodiment, the at least one organosulfur component is substantially free of metal, which typically means less than about 10 weight percent metal, preferably less than about 3 weight percent metal, more preferably less than about 1 weight percent metal, and most preferably only trace amounts of metal, such as less than about 0.01 weight percent.

As used herein when referring to the invention, the term "organosulfur compound(s)" or "organosulfur component(s)," means at least one of 4,4'-diphenyl disulfide; 4,4'-ditolyl disulfide; 2,2'-benzamido diphenyl disulfide; bis(2-aminophenyl)disulfide; bis(4-aminophenyl)disulfide; bis(3-aminophenyl)disulfide; 2,2'-bis(4-aminonaphthyl)disulfide; 2,2'-bis(3-aminonaphthyl)disulfide; 2,2'-bis(4-aminonaphthyl)disulfide; 2,2'-bis(5-aminonaphthyl)disulfide; 2,2'-bis(6-aminonaphthyl)disulfide; 2,2'-bis(7-aminonaphthyl)disulfide; 2,2'-bis(8-aminonaphthyl)disulfide; 1,1'-bis(2-aminonaphthyl)disulfide; 1,1'-bis(3-aminonaphthyl)disulfide; 1,1'-bis(4-aminonaphthyl)disulfide; 1,1'-bis(5-aminonaphthyl)disulfide; 1,1'-bis(6-aminonaphthyl)disulfide; 1,1'-bis(7-aminonaphthyl)disulfide; 1,1'-bis(8-aminonaphthyl)disulfide; 1,2'-diamino-1,2'-dithiodinaphthalene; 2,3'-diamino-1,2'-dithiodinaphthalene; bis(4-chlorophenyl)disulfide; bis(2-chlorophenyl)disulfide; bis(3-chlorophenyl)disulfide; bis(4-bromophenyl)disulfide;

US 6,486,261 B1

13

bis(2-bromophenyl)disulfide; bis(3-bromophenyl)disulfide; bis(4-fluorophenyl)disulfide; bis(4-iodophenyl)disulfide; bis(2,5-dichlorophenyl)disulfide; bis(3,5-dichlorophenyl)disulfide; bis(2,4-dichlorophenyl)disulfide; bis(2,6-dichlorophenyl)disulfide; bis(2,5-dibromophenyl)disulfide; bis(3,5-dibromophenyl)disulfide; bis(2-chloro-5-bromophenyl)disulfide; bis(2,4,6-trichlorophenyl)disulfide; bis(2,3,4,5,6-pentachlorophenyl)disulfide; bis(4-cyanophenyl)disulfide; bis(2-cyanophenyl)disulfide; bis(4-nitrophenyl)disulfide; bis(2-nitrophenyl)disulfide; 2,2'-dithiobenzoic acid ethylester; 2,2'-dithiobenzoic acid methylester; 2,2'-dithiobenzoic acid; 4,4'-dithiobenzoic acid ethylester; bis(4-acetylphenyl)disulfide; bis(2-acetylphenyl)disulfide; bis(4-formylphenyl)disulfide; bis(4-carbamoylphenyl)disulfide; 1,1'-dinaphthyl disulfide; 2,2'-dinaphthyl disulfide; 1,2'-dinaphthyl disulfide; 2,2'-bis(1-chlorodinaphthyl)disulfide; 2,2'-bis(1-bromodinaphthyl)disulfide; 1,1'-bis(2-chlorodinaphthyl)disulfide; 2,2'-bis(1-cyanodinaphthyl)disulfide; 2,2'-bis(1-acetylnaphthyl)disulfide; and the like; or a mixture thereof. Preferred organosulfur components include 4,4'-diphenyl disulfide, 4,4'-ditolyl disulfide, or 2,2'-benzamido diphenyl disulfide, or a mixture thereof. A more preferred organosulfur component includes 4,4'-ditolyl disulfide. The organosulfur cis-to-trans catalyst, when present, is preferably present in an amount sufficient to produce the reaction product so as to contain at least about 12 percent trans-polybutadiene isomer, but typically is greater than about 32 percent trans-polybutadiene isomer based on the total resilient polymer component. Suitable metal-containing organosulfur components include, but are not limited to, cadmium, copper, lead, and tellurium analogs of diethyldithiocarbamate, diamylthiocarbamate, and dimethyldithiocarbamate, or mixtures thereof. Suitable substituted or unsubstituted aromatic organic components that do not include sulfur or a metal include, but are not limited to, 4,4'-diphenyl acetylene, azobenzene, or a mixture thereof. The aromatic organic group preferably ranges in size from C₆ to C₁₀, and more preferably from C₆ to C₁₀. Suitable inorganic sulfide components include, but are not limited to titanium sulfide, manganese sulfide, and sulfide analogs of iron, calcium, cobalt, molybdenum, tungsten, copper, selenium, yttrium, zinc, tin, and bismuth. The cis-to-trans catalyst may also be a blend of an organosulfur component and an inorganic sulfide component.

A substituted or unsubstituted aromatic organic compound may also be included in the cis-to-trans catalyst. In one embodiment, the aromatic organic compound is substantially free of metal. Suitable substituted or unsubstituted aromatic organic components include, but are not limited to, components having the formula (R₁)_x-R₃-M-R₄-(R₂)_y, wherein R₁ and R₂ are each hydrogen or a substituted or unsubstituted C₁₋₂₀ linear, branched, or cyclic alkyl, alkoxy, or alkylthio group, or a single, multiple, or fused ring C₆ to C₂₄ aromatic group; x and y are each an integer from 0 to 5; R₃ and R₄ are each selected from a single, multiple, or fused ring C₆ to C₂₄ aromatic group; and M includes an azo group or a metal component. R₃ and R₄ are each preferably selected from a C₆ to C₁₀ aromatic group, more preferably selected from phenyl, benzyl, naphthyl, benzamido, and benzothiazyl. R₁ and R₂ are each preferably selected from a substituted or unsubstituted C₁₋₁₀ linear, branched, or cyclic alkyl, alkoxy, or alkylthio group or a C₆ to C₁₀ aromatic group. When R₁, R₂, R₃, or R₄ are substituted, the substitution may include one or more of the following substituent groups: hydroxy and metal salts thereof; mercapto and metal salts thereof; halogen; amino, nitro, cyano, and amido; carboxyl including esters, acids, and metal salts thereof;

14

silyl; acrylates and metal salts thereof; sulfonyl or sulfonamide; and phosphates and phosphites. When M is a metal component, it may be any suitable elemental metal available to those of ordinary skill in the art. Typically, the metal will be a transition metal, although preferably it is tellurium or selenium.

The cis-to-trans catalyst can also include a Group VIA component, as defined herein. Elemental sulfur and polymeric sulfur are commercially available from, e.g., Elastochem, Inc. of Chardon, Ohio. Exemplary sulfur catalyst compounds include PB(RM-S)-80 elemental sulfur and PB(CRST)-65 polymeric sulfur, each of which is available from Elastochem, Inc. An exemplary tellurium catalyst under the tradename TELLOY and an exemplary selenium catalyst under the tradename VANDEX are each commercially available from RT Vanderbilt.

The cis-to-trans catalyst is preferably present in an amount from about 0.1 to 10 parts per hundred of the total resilient polymer component. More preferably, the cis-to-trans catalyst is present in an amount from about 0.1 to 5 parts per hundred of the total resilient polymer component. Most preferably, the cis-to-trans catalyst is present in an amount from about 0.1 to 8 parts per hundred of the total resilient polymer component. The cis-to-trans catalyst is typically present in an amount sufficient to produce the reaction product so as to increase the trans-polybutadiene isomer content to contain from about 5 percent to 70 percent trans-polybutadiene based on the total resilient polymer component.

The measurement of trans-isomer content of polybutadiene referred to herein was and can be accomplished as follows. Calibration standards are prepared using at least two polybutadiene rubber samples of known trans-content, e.g., high and low percent trans-polybutadiene. These samples are used alone and blended together in such a way as to create a ladder of trans-polybutadiene content of at least about 1.5% to 50% or to bracket the unknown amount, such that the resulting calibration curve contains at least about 13 equally spaced points.

Using a commercially available Fourier Transform Infrared ("FTIR") spectrometer equipped with a Photoacoustic ("PAS") cell, a PAS spectrum of each standard was obtained using the following instrument parameters: scan at speed of 2.5 KHz (0.16 cm/s optical velocity), use a 1.2 KHz electronic filter, set an undersampling ratio of 2 (number of laser signal zero crossings before collecting a sample), co-add a minimum of 128 scans at a resolution of 4 cm⁻¹ over a range of 375 to 4000 cm⁻¹ with a sensitivity setting of 1.

The cis-, trans-, and vinyl-polybutadiene peaks are typically found between 600 and 1100 cm⁻¹ in the PAS spectrum. The area under each of the trans-polybutadiene peaks can be integrated. Determining the fraction of each peak area relative to the total area of the three isomer peaks allow construction of a calibration curve of the trans-polybutadiene area fraction versus the actual trans-polybutadiene content. The correlation coefficient (R²) of the resulting calibration curve must be a minimum of 0.95.

A PAS spectrum is obtained, using the parameters described above, for the unknown core material at the point of interest (e.g., the surface or center of the core) by filling the PAS cell with a sample containing a freshly cut, uncontaminated surface free of foreign matters, such as mold release and the like. The trans-polybutadiene area fraction of the unknown is analyzed to determine the actual trans-isomer content from the calibration curve.

In one known circumstance when barium sulfate is included, the above method for testing trans-content may be

US 6,486,261 B1

15

less accurate. Thus, an additional or alternative test of the trans-content of polybutadiene is as follows. Calibration standards are prepared using at least two polybutadienes of known trans-content (e.g., high and low percent trans-polybutadiene). These samples are used alone and blended together in such a way as to create a ladder of trans-polybutadiene content of at least about 1.5% to 50% or to bracket the unknown amount, such that the resulting calibration curve contains at least about 13 equally spaced points.

Using a Fourier Transform Raman ("FT-Raman") spectrometer equipped with a near-infrared laser, a Stokes Raman spectrum should be obtained from each standard using the following instrument parameters: sufficient laser power to obtain a good signal-to-noise ratio ("S/N") without causing excessive heating or fluorescence (typically about 400 to 800 mW is suitable); a resolution of 2 cm^{-1} ; over a Raman shift spectral range of about 400 to 4000 cm^{-1} ; and co-adding at least 300 scans.

A calibration curve may be constructed from the data generated above, using a chemometrics approach and software such as PLSplus/IQ from Galactic Industries Corp. of Salem, N.H. An acceptable calibration was obtained with this software using a PLS-1 curve generated using an SNV (detrend) pathlength correction, a mean center data preparation, and a 5-point SG second derivative over the spectral range from about 1600 to 1700 cm^{-1} . The correlation coefficient (R^2) of the resulting calibration curve must be a minimum of 0.95.

A Raman spectrum of the core material is obtained using this instrument at the point of interest in the sample (e.g., surface or center of the golf ball core). The sample must be free of foreign matter, such as mold release, etc. Analyze the spectrum of the sample using the PLS calibration curve to determine trans-polybutadiene isomer content of the sample.

A free-radical source, often alternatively referred to as a free-radical initiator, is required in the composition and method. The free-radical source is typically a peroxide, and preferably an organic peroxide. Suitable free-radical sources include di-t-amyl peroxide, di(2-t-butyl-peroxyisopropyl) benzene peroxide, 1,1-bis(t-butylperoxy)-3,3,5-trimethylcyclohexane, dicumyl peroxide, di-t-butyl peroxide, 2,5-di-(t-butylperoxy)-2,5-dimethyl hexane, n-butyl-4,4-bis(t-butylperoxy)valerate, lauryl peroxide, benzoyl peroxide, t-butyl hydroperoxide, and the like, and any mixture thereof. The peroxide is typically present in an amount greater than about 0.1 parts per hundred of the total resilient polymer component, preferably about 0.1 to 15 parts per hundred of the resilient polymer component, and more preferably about 0.2 to 5 parts per hundred of the total resilient polymer component. It should be understood by those of ordinary skill in the art that the presence of certain cis-to-trans catalysts according to the invention may require a larger amount of free-radical source, such as the amounts described herein, compared to conventional cross-linking reactions. The free radical source may alternatively or additionally be one or more of an electron beam, UV or gamma radiation, x-rays, or any other high energy radiation source capable of generating free radicals. It should be further understood that heat often facilitates initiation of the generation of free radicals.

Crosslinkers are included to increase the hardness of the reaction product. Suitable crosslinking agents include one or more metallic salts of unsaturated fatty acids or monocarboxylic acids, such as zinc, calcium, or magnesium acrylate salts, and the like, and mixtures thereof. Preferred acrylates

16

include zinc acrylate, zinc diacrylate, zinc methacrylate, and zinc dimethacrylate, and mixtures thereof. The crosslinking agent must be present in an amount sufficient to crosslink a portion of the chains of polymers in the resilient polymer component. For example, the desired compression may be obtained by adjusting the amount of crosslinking. This may be achieved, for example, by altering the type and amount of crosslinking agent, a method well-known to those of ordinary skill in the art. The crosslinking agent is typically present in an amount greater than about 0.1 percent of the resilient polymer component, preferably from about 10 to 40 percent of the resilient polymer component, more preferably from about 10 to 30 percent of the resilient polymer component. When an organosulfur is selected as the cis-to-trans catalyst, zinc diacrylate may be selected as the crosslinking agent and is present in an amount of less than about 25 phr.

Fillers added to one or more portions of the golf ball typically include processing aids or compounds to affect rheological and mixing properties, the specific gravity (i.e., density-modifying fillers), the modulus, the tear strength, reinforcement, and the like. The fillers are generally inorganic, and suitable fillers include numerous metals or metal oxides, such as zinc oxide and tin oxide, as well as barium sulfate, zinc sulfate, calcium carbonate, barium carbonate, clay, tungsten, tungsten carbide, an array of silicas, and mixtures thereof. Fillers may also include various foaming agents or blowing agents which may be readily selected by one of ordinary skill in the art. Polymeric, ceramic, metal, and glass microspheres may be solid or hollow, and filled or unfilled. Fillers are typically also added to one or more portions of the golf ball to modify the density thereof to conform to uniform golf ball standards. Fillers may also be used to modify the weight of the center or at least one additional layer for specialty balls, e.g., a lower weight ball is preferred for a player having a low swing speed.

The polymers, free-radical initiator, filler(s), and any other materials used in forming either the golf ball center or any portion of the core, in accordance with invention, may be combined to form a mixture by any type of mixing known to one of ordinary skill in the art. Suitable types of mixing include single pass and multi-pass mixing, and the like. The crosslinking agent, and any other optional additives used to modify the characteristics of the golf ball center or additional layer(s), may similarly be combined by any type of mixing. A single-pass mixing process where ingredients are added sequentially is preferred, as this type of mixing tends to increase efficiency and reduce costs for the process. The preferred mixing cycle is single step wherein the polymer, cis-trans catalyst, filler, zinc diacrylate, and peroxide are added sequentially. Suitable mixing equipment is well known to those of ordinary skill in the art, and such equipment may include a Banbury mixer, a two-roll mill, or a twin screw extruder. Conventional mixing speeds for combining polymers are typically used, although the speed must be high enough to impart substantially uniform dispersion of the constituents. On the other hand, the speed should not be too high, as high mixing speeds tend to break down the polymers being mixed and particularly may undesirably decrease the molecular weight of the resilient polymer component. The speed should thus be low enough to avoid high shear, which may result in loss of desirably high molecular weight portions of the polymer component. Also, too high a mixing speed may undesirably result in creation of enough heat to initiate the crosslinking before the pre-forms are shaped and assembled around a core. The mixing temperature depends upon the type of polymer components,

US 6,486,261 B1

17

and more importantly, on the type of free-radical initiator. For example, when using di(2-t-butyl-peroxyisopropyl) benzene as the free-radical initiator, a mixing temperature of about 80° C. to 125° C., preferably about 88° C. to 110° C., and more preferably about 90° C. to 100° C., is suitable to safely mix the ingredients. Additionally, it is important to maintain a mixing temperature below the peroxide decomposition temperature. For example, if dicumyl peroxide is selected as the peroxide, the temperature should not exceed 200° F. Suitable mixing speeds and temperatures are well-known to those of ordinary skill in the art, or may be readily determined without undue experimentation.

The mixture can be subjected to, e.g., a compression or injection molding process, to obtain solid spheres for the center or hemispherical shells for forming an intermediate layer. The polymer mixture is subjected to a molding cycle in which heat and pressure are applied while the mixture is confined within a mold. The cavity shape depends on the portion of the golf ball being formed. The compression and heat liberates free radicals by decomposing one or more peroxides, which may initiate the cis-to-trans conversion and crosslinking simultaneously. The temperature and duration of the molding cycle are selected based upon the type of peroxide and cis-trans catalyst selected. The molding cycle may have a single step of molding the mixture at a single temperature for a fixed time duration. An example of a single step molding cycle, for a mixture that contains dicumyl peroxide, would hold the polymer mixture at 340° F. for a duration of 15 minutes. The molding cycle may also include a two-step process, in which the polymer mixture is held in the mold at an initial temperature for an initial duration of time, followed by holding at a second, typically higher temperature for a second duration of time. An example of a two-step molding cycle would be holding the mold at 290° F. for 40 minutes, then ramping the mold to 340° F. where it is held for a duration of 20 minutes. In a preferred embodiment of the current invention, a single-step cure cycle is employed. Single-step processes are effective and efficient, reducing the time and cost of a two-step process. The resilient polymer component, polybutadiene, cis-to-trans conversion catalyst, additional polymers, free-radical initiator, filler, and any other materials used in forming either the golf ball center or any portion of the core, in accordance with the invention, may be combined to form a golf ball by an injection molding process, which is also well-known to one of ordinary skill in the art. Although the curing time depends on the various materials selected, a particularly suitable curing time is about 5 to 18 minutes, preferably from about 8 to 15 minutes, and more preferably from about 10 to 12 minutes. Those of ordinary skill in the art will be readily able to adjust the curing time upward or downward based on the particular materials used and the discussion herein.

The cured resilient polymer component, which contains a greater amount of trans-polybutadiene than the uncured resilient polymer component, is formed into an article having a first hardness at a point in the interior and a surface having a second hardness such that the second hardness differs from the first hardness by greater than 10 percent of the first hardness. Preferably, the article is a sphere and the point is the midpoint of the article. In another embodiment, the second hardness differs from the first by greater than 20 percent of the first hardness. The cured article also has a first amount of trans-polybutadiene at an interior location and a second amount of trans-polybutadiene at a surface location, wherein the first amount is at least about 6 percent less than the second amount, preferably at least about 10 percent less

18

than the second amount, and more preferably at least about 20 percent less than the second amount. The interior location is preferably a midpoint and the article is preferably a sphere. The compression of the core, or portion of the core, of golf balls prepared according to the invention is preferably below about 50, more preferably below about 25.

The cover provides the interface between the ball and a club. Properties that are desirable for the cover are good moldability, high abrasion resistance, high tear strength, high resilience, and good mold release, among others. The cover typically has a thickness to provide sufficient strength, good performance characteristics and durability. The cover preferably has a thickness of less than about 0.1 inches, more preferably, less than about 0.05 inches, and most preferably, between about 0.02 and about 0.04 inches. The invention is particularly directed towards a multilayer golf ball which comprises a core, an inner cover layer, and an outer cover layer. In this embodiment, preferably, at least one of the inner and outer cover layers has a thickness of less than about 0.05 inches, more preferably between about 0.02 and about 0.04 inches. Most preferably, the thickness of either layer is about 0.03 inches.

When the golf ball of the present invention includes an intermediate layer, such as an inner cover layer, this layer can include any materials known to those of ordinary skill in the art, including thermoplastic and thermosetting materials, but preferably the intermediate layer can include any suitable materials, such as ionic copolymers of ethylene and an unsaturated monocarboxylic acid which are available under the trademark SURLYN of E.I. DuPont de Nemours & Co., of Wilmington, Del., or IOTEK or ESCOR of Exxon. These are copolymers or terpolymers of ethylene and methacrylic acid or acrylic acid partially neutralized with salts of zinc, sodium, lithium, magnesium, potassium, calcium, manganese, nickel or the like, in which the salts are the reaction product of an olefin having from 2 to 8 carbon atoms and an unsaturated monocarboxylic acid having 3 to 8 carbon atoms. The carboxylic acid groups of the copolymer may be totally or partially neutralized and might include methacrylic, crotonic, maleic, fumaric or itaconic acid.

This golf ball can likewise include one or more homopolymeric or copolymeric intermediate materials, such as:

- (1) Vinyl resins, such as those formed by the polymerization of vinyl chloride, or by the copolymerization of vinyl chloride with vinyl acetate, acrylic esters or vinylidene chloride;
- (2) Polyolefins, such as polyethylene, polypropylene, polybutylene and copolymers such as ethylene methylacrylate, ethylene ethylacrylate, ethylene vinyl acetate, ethylene methacrylic or ethylene acrylic acid or propylene acrylic acid and copolymers and homopolymers produced using a single-site catalyst or a metallocene catalyst;
- (3) Polyurethanes, such as those prepared from polyols and diisocyanates or polyisocyanates and those disclosed in U. S. Pat. No. 5,334,673;
- (4) Polyureas, such as those disclosed in U.S. Pat. No. 5,484,870;
- (5) Polyamides, such as poly(hexamethylene adipamide) and others prepared from diamines and dibasic acids, as well as those from amino acids such as poly(caprolactam), and blends of polyamides with SURLYN, polyethylene, ethylene copolymers, ethylpropylene-non-conjugated diene terpolymer, and the like;

US 6,486,261 B1

19

- (6) Acrylic resins and blends of these resins with poly vinyl chloride, elastomers, and the like;
- (7) Thermoplastics, such as urethanes; olefinic thermoplastic rubbers, such as blends of polyolefins with ethylene-propylene-non-conjugated diene terpolymer; block copolymers of styrene and butadiene, isoprene or ethylene-butylene rubber; or copoly(ether-amide), such as PEBAX, sold by ELF Atochem of Philadelphia, Pa.;
- (8) Polyphenylene oxide resins or blends of polyphenylene oxide with high impact polystyrene as sold under the trademark NORYL by General Electric Company of Pittsfield, Mass.;
- (9) Thermoplastic polyesters, such as polyethylene terephthalate, polybutylene terephthalate, polyethylene terephthalate/glycol modified and elastomers sold under the trademarks HYTREL by E.I. DuPont de Nemours & Co. of Wilmington, Del., and LOMOD by General Electric Company of Pittsfield, Mass.;
- (10) Blends and alloys, including polycarbonate with acrylonitrile butadiene styrene, polybutylene terephthalate, polyethylene terephthalate, styrene maleic anhydride, polyethylene, elastomers, and the like, and polyvinyl chloride with acrylonitrile butadiene styrene or ethylene vinyl acetate or other elastomers; and
- (11) Blends of thermoplastic rubbers with polyethylene, propylene, polyacetal, nylon, polyesters, cellulose esters, and the like.

Preferably, the optional intermediate layer includes polymers, such as ethylene, propylene, butene-1 or hexene-1 based homopolymers or copolymers including functional monomers, such as acrylic and methacrylic acid and fully or partially neutralized ionomer resins and their blends, methyl acrylate, methyl methacrylate homopolymers and copolymers, imidized, amino group containing polymers, polycarbonate, reinforced polyamides, polyphenylene oxide, high impact polystyrene, polyether ketone, polysulfone, poly(phenylene sulfide), acrylonitrile-butadiene, acrylic-styrene-acrylonitrile, poly(ethylene terephthalate), poly(butylene terephthalate), poly(ethylene vinyl alcohol), poly(tetrafluoroethylene) and their copolymers including functional comonomers, and blends thereof. Suitable cover compositions also include a polyether or polyester thermoplastic urethane, a thermoset polyurethane, a low modulus ionomer, such as acid-containing ethylene copolymer ionomers, including E/X/Y terpolymers where E is ethylene, X is an acrylate or methacrylate-based softening comonomer present in about 0 to 50 weight percent and Y is acrylic or methacrylic acid present in about 5 to 35 weight percent. More preferably, in a low spin rate embodiment designed for maximum distance, the acrylic or methacrylic acid is present in about 15 to 35 weight percent, making the ionomer a high modulus ionomer. In a high spin embodiment, the cover includes an ionomer where an acid is present in about 10 to 15 weight percent and includes a softening comonomer.

The cover preferably include a polyurethane composition comprising the reaction product of at least one polyisocyanate, polyol, and at least one curing agent.

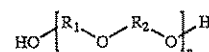
Any polyisocyanate available to one of ordinary skill in the art is suitable for use according to the invention. Exemplary polyisocyanates include, but are not limited to, 4,4'-diphenylmethane diisocyanate ("MDI"), polymeric MDI, carbodiimide-modified liquid MDI, 4,4'-dicyclohexylmethane diisocyanate ("H₁₂MDI"), p-phenylene diisocyanate ("PPDI"), toluene diisocyanate

20

("TDI"), 3,3'-dimethyl-4,4'-biphenylene diisocyanate ("TODI"), isophoronediiisocyanate ("IPDI"), hexamethylene diisocyanate ("HDI"), naphthalene diisocyanate ("NDI"); xylene diisocyanate ("XDI"); para-tetramethylxylene diisocyanate ("p-TMXDI"); meta-tetramethylxylene diisocyanate ("m-TMXDI"); ethylene diisocyanate; propylene-1,2-diisocyanate; tetramethylene-1,4-diisocyanate; cyclohexyl diisocyanate; 1,6-hexamethylene-diisocyanate ("HDI"); dodecane-1,12-diisocyanate; cyclobutane-1,3-diisocyanate; cyclohexane-1,3-diisocyanate; cyclohexane-1,4-diisocyanate; 1-isocyanato-3,3,5-trimethyl-5-isocyanatomethylcyclohexane; methyl cyclohexylene diisocyanate; triisocyanate of HDI; triisocyanate of 2,4,4-trimethyl-1,6-hexane diisocyanate ("TMDI"), tetracene diisocyanate, naphthalene diisocyanate, anthracene diisocyanate, and mixtures thereof. Polyisocyanates are known to those of ordinary skill in the art as having more than one isocyanate group, e.g., di-, tri-, and tetra-isocyanate. Preferably, the polyisocyanate includes MDI, PPDI, TDI, or a mixture thereof, and more preferably, the polyisocyanate includes MDI. It should be understood that, as used herein, the term "MDI" includes 4,4'-diphenylmethane diisocyanate, polymeric MDI, carbodiimide-modified liquid MDI, and mixtures thereof and, additionally, that the diisocyanate employed may be "low free monomer," understood by one of ordinary skill in the art to have lower levels of "free" monomer isocyanate groups, typically less than about 0.1% free monomer groups. Examples of "low free monomer" diisocyanates include, but are not limited to Low Free Monomer MDI, Low Free Monomer TDI, and Low Free Monomer PPDI.

The at least one polyisocyanate should have less than about 14% unreacted NCO groups. Preferably, the at least one polyisocyanate has no greater than about 7.5% NCO, more preferably, between about 2.5% and about 7.5%, and most preferably, between about 4% to about 6.5%.

Any polyol available to one of ordinary skill in the art is suitable for use according to the invention. Exemplary polyols include, but are not limited to, polyether polyols, hydroxy-terminated polybutadiene (including partially/fully hydrogenated derivatives), polyester polyols, polycaprolactone polyols, and polycarbonate polyols. In one preferred embodiment, the polyol includes polyether polyol, more preferably those polyols that have the generic structure:

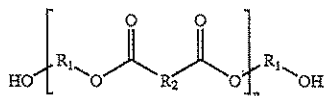


where R₁ and R₂ are straight or branched hydrocarbon chains, each containing from 1 to about 20 carbon atoms, and n ranges from 1 to about 45. Examples include, but are not limited to, polytetramethylene ether glycol ("PTMEG"), polyethylene propylene glycol, polyoxypropylene glycol, and mixtures thereof. The hydrocarbon chain can have saturated or unsaturated bonds and substituted or unsubstituted aromatic and cyclic groups. Preferably, the polyol of the present invention includes PTMEG.

In another embodiment, polyester polyols are included in the polyurethane material of the invention. Preferred polyester polyols have the generic structure:

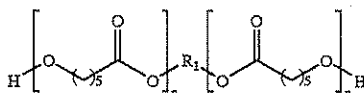
US 6,486,261 B1

21



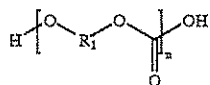
where R_1 and R_2 are straight or branched hydrocarbon chains, each containing from 1 to about 20 carbon atoms, and n ranges from 1 to about 25. Suitable polyester polyols include, but are not limited to, polyethylene adipate glycol, polybutylene adipate glycol, polyethylene propylene adipate glycol, ortho-phthalate-1,6-hexanediol, and mixtures thereof. The hydrocarbon chain can have saturated or unsaturated bonds, or substituted or unsubstituted aromatic and cyclic groups.

In another embodiment, polycaprolactone polyols are included in the materials of the invention. Preferably, any polycaprolactone polyols have the generic structure:



where R_1 is a straight chain or branched hydrocarbon chain containing from 1 to about 20 carbon atoms, and n is the chain length and ranges from 1 to about 20. Suitable polycaprolactone polyols include, but are not limited to, 1,6-hexanediol-initiated polycaprolactone, diethylene glycol initiated polycaprolactone, trimethylol propane initiated polycaprolactone, neopentyl glycol initiated polycaprolactone, 1,4-butanediol-initiated polycaprolactone, and mixtures thereof. The hydrocarbon chain can have saturated or unsaturated bonds, or substituted or unsubstituted aromatic and cyclic groups.

In yet another embodiment, the polycarbonate polyols are included in the polyurethane material of the invention. Preferably, any polycarbonate polyols have the generic structure:



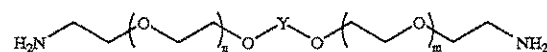
where R_1 is predominantly bisphenol A units $-(\text{p-C}_6\text{H}_4)-\text{C}(\text{CH}_3)_2-(\text{p-C}_6\text{H}_4)-$ or derivatives thereof, and n is the chain length and ranges from 1 to about 20. Suitable polycarbonates include, but are not limited to, polyphthalate carbonate. The hydrocarbon chain can have saturated or unsaturated bonds, or substituted or unsubstituted aromatic and cyclic groups. In one embodiment, the molecular weight of the polyol is from about 200 to about 4000.

Polyamine curatives are also suitable for use in the polyurethane composition of the invention and have been found to improve cut, shear, and impact resistance of the resultant balls. Preferred polyamine curatives include, but are not limited to, 3,5-dimethylthio-2,4-toluenediamine and isomers thereof, 3,5-diethyltoluene-2,4-diamine and isomers thereof, such as 3,5-diethyltoluene-2,6-diamine; 4,4'-bis-(sec-butylamino)-diphenylmethane; 1,4-bis-(sec-butylamino)-benzene, 4,4'-methylene-bis-(2-chloroaniline); 4,4'-methylene-bis-(3-chloro-2,6-diethylaniline); polytetramethyleneoxide-di-p-aminobenzoate; $\text{N,N}'$ -dialkyldiamino diphenyl methane; $\text{p,p}'$ -methylene dianiline ("MDA"); m -phenylenediamine ("MPDA"); 4,4'-methylene-bis-(2-chloroaniline) ("MOCA"); 4,4'-

22

methylene-bis-(2,6-diethylaniline); 4,4'-diamino-3,3'-diethyl-5,5'-dimethyl diphenylmethane; 2,2',3,3'-tetrachloro diamino diphenylmethane; 4,4'-methylene-bis-(3-chloro-2,6-diethylaniline); trimethylene glycol di-p-aminobenzoate; and mixtures thereof. Preferably, the curing agent of the present invention includes 3,5-dimethylthio-2,4-toluenediamine and isomers thereof, such as ETHACURE 300, commercially available from Albemarle Corporation of Baton Rouge, La. Suitable polyamine curatives, which include both primary and secondary amines, preferably have molecular weights ranging from about 64 to about 2000.

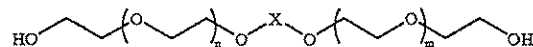
Other suitable polyamine curatives include those having the general formula:



where n and m each separately have values of 0, 1, 2, or 3, and where Y is 1,2-cyclohexyl, 1,3-cyclohexyl, 1,4-cyclohexyl, ortho-phenylene, meta-phenylene, or para-phenylene, or a combination thereof. Preferably, n and m , each separately, have values of 0, 1, or 2, and preferably, 1 or 2.

At least one of a diol, triol, tetraol, or hydroxy-terminated curatives may be added to the aforementioned polyurethane composition. Suitable diol, triol, and tetraol groups include ethylene glycol; diethylene glycol; polyethylene glycol; propylene glycol; polypropylene glycol; lower molecular weight polytetramethylene ether glycol; 1,3-bis(2-hydroxyethoxy)benzene; 1,3-bis-[2-(2-hydroxyethoxy)ethoxy]benzene; 1,3-bis-[2-[2-(2-hydroxyethoxy)ethoxy]ethoxy]benzene; 1,4-butanediol; 1,5-pentanediol; 1,6-hexanediol; resorcinol-di-(β -hydroxyethyl)ether; hydroquinone-di-(β -hydroxyethyl)ether; and mixtures thereof. Preferred hydroxy-terminated curatives include ethylene glycol; diethylene glycol; 1,4-butanediol; 1,5-pentanediol; 1,6-hexanediol, trimethylol propane, and mixtures thereof.

Preferably, the hydroxy-terminated curatives have molecular weights ranging, from about 48 to 2000. It should be understood that molecular weight, as used herein, is the absolute weight average molecular weight and would be understood as such by one of ordinary skill in the art. Other suitable hydroxy-terminated curatives have the following general chemical structure:



where n and m each separately have values of 0, 1, 2, or 3, and where X is ortho-phenylene, meta-phenylene, para-phenylene, 1,2-cyclohexyl, 1,3-cyclohexyl, or 1,4-cyclohexyl, or mixtures thereof. Preferably, n and m each separately have values of 0, 1, or 2, and more preferably, 1 or 2.

Both the hydroxy-terminated and amine curatives can include one or more saturated, unsaturated, aromatic, and cyclic groups. Additionally, the hydroxy-terminated and amine curatives can include one or more halogen groups. The polyurethane composition can be formed with a blend or mixture of curing agents. If desired, however, the polyurethane composition may be formed with a single curing agent.

Any method known to one of ordinary skill in the art may be used to combine the polyisocyanate, polyol, and curing agent of the present invention. One commonly employed

US 6,486,261 B1

23

method, known in the art as a one-shot method, involves concurrent mixing of the polyisocyanate, polyol, and curing agent. This method results in a mixture that is inhomogeneous (more random) and affords the manufacturer less control over the molecular structure of the resultant composition. A preferred method of mixing is known as a prepolymer method. In this method, the polyisocyanate and the polyol are mixed separately prior to addition of the curing agent. This method affords a more homogeneous mixture resulting in a more consistent polymer composition.

An optional filler component may be chosen to impart additional density to blends of the previously described components. The selection of such filler(s) is dependent upon the type of golf ball desired (i.e., one-piece, two-piece multi-component, or wound). Examples of useful fillers include zinc oxide, barium sulfate, calcium oxide, calcium carbonate and silica, as well as the other well known corresponding salts and oxides thereof. Additives, such as nanoparticles, glass spheres, and various metals, such as titanium and tungsten, can be added to the polyurethane compositions of the present invention, in amounts as needed, for their well-known purposes. Additional components which can be added to the polyurethane composition include UV stabilizers and other dyes, as well as optical brighteners and fluorescent pigments and dyes. Such additional ingredients may be added in any amounts that will achieve their desired purpose.

Due to the very thin nature, it has been found by the present invention that the use of a castable, reactive material, which is applied in a fluid form, makes it possible to obtain very thin outer cover layers on golf balls. Specifically, it has been found that castable, reactive liquids, which react to form a urethane elastomer material, provide desirable very thin outer cover layers.

The castable, reactive liquid employed to form the urethane elastomer material can be applied over the inner core using a variety of application techniques such as spraying, dipping, spin coating, or flow coating methods which are well known in the art. An example of a suitable coating technique is that which is disclosed in U.S. Pat. No. 5,733,428, filed May 2, 1995 entitled "Method And Apparatus For Forming Polyurethane Cover On A Golf Ball", the disclosure of which is hereby incorporated by reference in its entirety in the present application.

The cover is preferably formed around the coated core by mixing and introducing the material in the mold halves. It is important that the viscosity be measured over time, so that the subsequent steps of filling each mold half, introducing the core into one half and closing the mold can be properly timed for accomplishing centering of the core cover halves fusion and achieving overall uniformity. Suitable viscosity range of the curing urethane mix for introducing cores into the mold halves is determined to be approximately between about 2,000 cP and about 30,000 cP, with the preferred range of about 8,000 cP to about 15,000 cP.

To start the cover formation, mixing of the prepolymer and curative is accomplished in motorized mixer including mixing head by feeding through lines metered amounts of curative and prepolymer. Top preheated mold halves are filled and placed in fixture units using pins moving into holes in each mold. After the reacting materials have resided in top mold halves for about 50 to about 80 seconds, a core is lowered at a controlled speed into the gelling reacting mixture. At a later time, a bottom mold half or a series of bottom mold halves have similar mixture amounts introduced into the cavity.

A ball cup holds the ball core through reduced pressure (or partial vacuum) in hose. Upon location of the coated core in

24

the halves of the mold after gelling for about 50 to about 80 seconds, the vacuum is released allowing core to be released. The mold halves, with core and solidified cover half thereon, are removed from the centering fixture unit, inverted and mated with other mold halves which, at an appropriate time earlier, have had a selected quantity of reacting polyurethane prepolymer and curing agent introduced therein to commence gelling.

Similarly, U.S. Pat. No. 5,006,297 to Brown et al. and U.S. Pat. No. 5,334,673 to Wu both also disclose suitable molding techniques which may be utilized to apply the castable reactive liquids employed in the present invention. The disclosures of these patents are hereby incorporated by reference in their entirety. However, the method of the invention is not limited to the use of these techniques.

Depending on the desired properties, balls prepared according to the invention can exhibit substantially the same or higher resilience, or coefficient of restitution ("COR"), with a decrease in compression or modulus, compared to balls of conventional construction. Additionally, balls prepared according to the invention can also exhibit substantially higher resilience, or COR, without an increase in compression, compared to balls of conventional construction. Another measure of this resilience is the "loss tangent," or $\tan \delta$, which is obtained when measuring the dynamic stiffness of an object. Loss tangent and terminology relating to such dynamic properties is typically described according to ASTM D4092-90. Thus, a lower loss tangent indicates a higher resiliency, thereby indicating a higher rebound capacity. Low loss tangent indicates that most of the energy imparted to a golf ball from the club is converted to dynamic energy, i.e., launch velocity and resulting longer distance. The rigidity or compressive stiffness of a golf ball may be measured, for example, by the dynamic stiffness. A higher dynamic stiffness indicates a higher compressive stiffness. To produce golf balls having a desirable compressive stiffness, the dynamic stiffness of the crosslinked reaction product material should be less than about 50,000 N/m at -50°C . Preferably, the dynamic stiffness should be between about 10,000 and 40,000 N/m at -50°C , more preferably, the dynamic stiffness should be between about 20,000 and 30,000 N/m at -50°C .

The dynamic stiffness is similar in some ways to dynamic modulus. Dynamic stiffness is dependent on probe geometry as described herein, whereas dynamic modulus is a unique material property, independent of geometry. The dynamic stiffness measurement has the unique attribute of enabling quantitative measurement of dynamic modulus and exact measurement of loss tangent at discrete points within a sample article. In the case of this invention, the article is a golf ball core. The polybutadiene reaction product preferably has a loss tangent below about 0.1 at -50°C , and more preferably below about 0.07 at -50°C .

The resultant golf balls typically have a coefficient of restitution of greater than about 0.7, preferably greater than about 0.75, and more preferably greater than about 0.78. The golf balls also typically have an Atti compression (which has been referred to as PGA compression in the past) of at least about 40, preferably from about 50 to 120, and more preferably from about 60 to 100. The golf ball polybutadiene material of the present invention typically has a flexural modulus of from about 500 psi to 300,000 psi, preferably from about 2000 to 200,000 psi. The golf ball polybutadiene material typically has a hardness of at least about 15 Shore A, preferably between about 30 Shore A and 80 Shore D, more preferably between about 50 Shore A and 60 Shore D. The specific gravity is typically greater than about 0.7,

US 6,486,261 B1

25

preferably greater than about 1, for the golf ball polybutadiene material.

The center composition should comprise at least one rubber material having a resilience index of at least about 40. Preferably the resilience index is at least about 50. A comparison of a number of polybutadiene polymers are listed in Table 1 below. Polymers that produce resilient golf balls and, therefore, are suitable for the present invention, include but are not limited to CB23, CB22, BR60, and 1207G. To clarify the method of computation for resilience index, the resilience index for CB23, for example, is computed as follows:

$$\text{Resilience Index for CB23} = 100,000 \cdot [(0.954) - (0.407)]^{990}$$

$$\text{Resilience Index for CB23} = 55$$

TABLE 1

Resilience Index of example polybutadiene polymers			
Rubber	Tan δ at		Resilience Index at
	10 cpm	1000 cpm	
CB23	0.954	0.407	55
CB22	0.895	0.358	54
BR-60	0.749	0.350	40
BR-40	0.841	0.446	40
Taktene 8855	0.720	0.414	31
CARIFLEX BR1220	0.487	0.439	5
BUDENE 1207G	0.825	0.388	44

26

tion typically has a Mooney viscosity of between about 40 and about 80, more preferably, between about 45 and about 60, and most preferably, between about 45 and about 55. Mooney viscosity is typically measured according to ASTM D-1646.

When golf balls are prepared according to the invention, they typically will have dimple coverage greater than about 60 percent, preferably greater than about 65 percent, and more preferably greater than about 75 percent. The flexural modulus of the cover on the golf balls, as measured by ASTM method D6272-98, Procedure B, is typically greater than about 500 psi, and is preferably from about 500 psi to 150,000 psi. As discussed herein, the outer cover layer is preferably formed from a relatively soft polyurethane material. In particular, the material of the outer cover layer should have a material hardness, as measured by ASTM-2240, between about 30 and about 60 Shore D, preferably from about 35 to about 55 Shore D. The inner cover layer, if present, preferably has a material hardness from about 50 to about 75 Shore D, preferably from about 60 to about 65 Shore D.

EXAMPLES

A variety of cores were prepared according to the present invention, as well as some cores prepared using conventional materials. All cores in Table 2 were prepared to a diameter of 1.58 inches. The recipes for each core, and values measured for compression and COR are presented in Table 2 below:

TABLE 2

Golf Ball Core Properties from Various Rubber Formulations						
Ingredients	Mooney viscosity					
	@ 100° C.	1	2	3	4	5
CB23	51	100				
CB22	63		100			
BR-60	60			100		
Taktene 8855	48				100	
CARIFLEX BR1220	43					100
zinc diacrylate		28	28	28	28	28
peroxide		0.53	0.53	0.53	0.53	0.53
zinc oxide		4.3	4.3	4.3	4.3	4.3
tungsten		11.0	11.0	11.0	11.0	11.0
Core Properties						
compression		77	75	77	76	71
COR @ 125 ft/s		0.815	0.811	0.810	0.807	0.802

The molding process and composition of golf ball portions typically results in a gradient of material properties. Methods employed in the prior art generally exploit hardness to quantify these gradients. Hardness is a qualitative measure of static modulus and does not represent the modulus of the material at the deformation rates associated with golf ball use, i.e., impact by a club. As is well known to one skilled in the art of polymer science, the time-temperature superposition principle may be used to emulate alternative deformation rates. For golf ball portions including polybutadiene, a 1-Hz oscillation at temperatures between 0° C. and -50° C. are believed to be qualitatively equivalent to golf ball impact rates. Therefore, measurement of loss tangent and dynamic stiffness at 0° C. to -50° C. may be used to accurately anticipate golf ball performance, preferably at temperatures between about -20° C. and -50° C.

Additionally, the unvulcanized rubber, such as polybutadiene, in golf balls prepared according to the inven-

A variety of metal sulfide cis-to-trans catalysts that successfully converted a portion of the cis-polybutadiene isomer to the trans-isomer are presented in Table 3. CARIFLEX BR1220 polybutadiene (100 phr) was reacted with zinc oxide (5 phr), dicumyl peroxide (3 phr, the free radical initiator), and zinc diacrylate (25 phr), to form the reaction product as described in the present invention.

Trans-isomer conversion percentages range from below 8 percent to above 17 percent for the various catalysts that are present in amounts ranging from below 1.7 phr to above 3.7 phr. The table clearly demonstrates the effectiveness of numerous different cis-to-trans catalysts, at varying concentrations, for increasing the trans-polybutadiene content.

US 6,486,261 B1

27

Example 1

A Core Prepared From According to the Invention,
Employing an Organosulfur Cis-to-Trans Catalyst

A core according to the present invention was created employing an organosulfur compound as the cis-to-trans conversion catalyst. The resultant core properties clearly demonstrate the advantages of a golf ball core made according to the current invention as compared to example cores constructed with conventional technology. The components and physical characteristics are presented in Table 4.

The compressive load of cores prepared according to the invention is approximately half of the compressive load of cores constructed in accordance with U.S. Pat. Nos. 5,697,856, 5,252,652, and 4,692,497, while at the same time retaining roughly the same, and in some cases higher, COR (resilience). The core made according to the current invention has a lower compressive load (soft), yet is resilient (fast). The compressive load is greater than that of a core constructed in accordance with U.S. Pat. No. 3,239,228, but has a significantly higher COR. The core of U.S. Pat. No. 3,239,228 is very soft and very slow (very low COR).

The percent change in dynamic stiffness from 0° C. to -50° C. was also measured at both the edge and center of the cores. The dynamic stiffness at both the edge and the center

28

of the core of the current invention varied only slightly, less than 20 percent, over the temperature range investigated. The core made according to U.S. Pat. No. 3,239,228 varied over 230 percent, whereas the cores made according to other conventional technology, had a dynamic stiffness that varied by greater than 130 percent, and typically by as much as 150 percent, over the same temperature range.

The percent of trans-conversion was also measured at both the center and edge of the core prepared according to the current invention, and for cores prepared as disclosed in the same four patents mentioned above, allowing a trans-gradient to be calculated. The core according to the current invention had a trans-gradient of about 32 percent from edge to center. For the core prepared according to the current invention, the pre- and post-cure trans-percentages was also measured to determine the effectiveness of that process. The percentage of polybutadiene converted to the trans-isomer ranged from almost 40 percent at the center to greater than 55 percent at the edge. Two of the cores prepared according to conventional technology, U.S. Pat. Nos. 3,239,228 and 4,692,497, had a zero trans-gradient. A third core, prepared according to U.S. Pat. No. 5,697,856, had only a slight trans-gradient, less than 18 percent from edge to center. A fourth core, prepared according to U.S. Pat. No. 5,252,652, had a very large gradient, almost 65 percent from edge to center.

TABLE 3

[illegible]

US 6,486,261 B1

29

30

TABLE 4

	Invention			Examples of Conventional Golf Balls			
	Examples			U.S. Pat. No.	U.S. Pat. No.	U.S. Pat. No.	U.S. Pat. No.
	#1	#2	#3	3239228	5816944	5252652	4971329
Chemical Constituents					U.S. Pat. No. 5697856		U.S. Pat. No. 4692497
Polybutadiene (Shell, CARIFLEX BR1220)	100	100	100		N/A	N/A	N/A
Polybutadiene (Firestone, 35 NF)				100	N/A	N/A	N/A
DMS				2.1	N/A	N/A	N/A
Carbon Black (RA)				15	N/A	N/A	N/A
Wood Flour				24	N/A	N/A	N/A
Sulfur				24	N/A	N/A	N/A
Stearic Acid				1.5	N/A	N/A	N/A
Reogen				15	N/A	N/A	N/A
Vanox MBPC				2	N/A	N/A	N/A
Triethanolamine				4	N/A	N/A	N/A
Zinc oxide	5	5	5	5	N/A	N/A	N/A
Dicumyl peroxide	3	1.9	2		N/A	N/A	N/A
Zinc Diacrylate	25	25	25		N/A	N/A	N/A
Cis-Trans "Catalyst"					N/A	N/A	N/A
MnS		0.82			N/A	N/A	N/A
Ditolylsulfide	2.5		1.5		N/A	N/A	N/A
Cu ₂ S			1		N/A	N/A	N/A
Resultant Core Properties							
Load (lbs) @ 10.8% Deflection 1.580" core	165.5	191.4	191.8	61.1	325	390	480
Coefficient of Restitution @ 125 ft/s	0.783	0.777	0.785	0.599	0.779	0.805	0.775
Hardness Shore C.							
Surface	61	76	62	35	75	80	80.5
Center	52	52	59	30	70	61	66.5
Dynamic Stiffness @ 0° C. (N/m)							
Edge*	25338	27676	28493	8312	62757	83032	72235
Center	20783	17390	27579	8361	61071	26264	50612
Dynamic Stiffness @ -50° C. (N/m)							
Edge*	30265	34523	34455	19394	92763	109053	108242
Center	23022	20603	32195	18617	89677	28808	83183
Dynamic Stiffness Ratio at -50° C./0° C.							
Edge*	119%	125%	121%	233%	148%	131%	150%
Center	111%	118%	117%	223%	147%	110%	164%
Loss Tangent 0° C.							
Edge*	0.024	0.027	0.024	0.074	0.039	0.037	0.045
Center	0.025	0.023	0.023	0.073	0.033	0.025	0.043
Loss Tangent -50° C.							
Edge*	0.098	0.084	0.097	0.183	0.142	0.119	0.099
Center	0.067	0.071	0.085	0.180	0.129	0.059	0.095
% Trans BR isomer Precure	1.5	1.5	1.5	50	N/A	N/A	N/A
% Trans BR isomer Postcure							
Surface	55.8	8.4	45.5	50	30.2	24.6	1.5
Center	37.8	4.6	25.5	50	24.7	8.5	1.5
% Trans Variation (Surf. - Center)/ Surf.	32%	45%	44%	0%	18%	65%	0%

*Edge is measured approximately 5 mm from the exterior surface of the measured article.

Example 2

A Core Prepared From According to the Invention,
Employing an Inorganic Sulfide Cis-to-trans
Catalyst

A core according to the present invention was created employing an inorganic sulfide compound as the cis-to-trans conversion catalyst. The resultant core properties clearly demonstrate the advantages of a golf ball core made according to the current invention as compared to example cores constructed with conventional technology. The components and physical characteristics are presented in Table 4.

The compressive load is approximately half of the compressive load of three cores constructed in accordance with

U.S. Pat. Nos. 5,697,856, 5,252,652, and 4,692,497, while at the same time retaining roughly the same, and in some cases, a higher COR (resilience). The core made according to the current invention is soft, yet resilient (fast). The compressive load is greater than a core constructed in accordance with U.S. Pat. No. 3,239,228, but has a significantly higher COR. The core of U.S. Pat. No. 3,239,228 is very soft and very slow (low COR).

The percent change in dynamic stiffness from 0° C. to -50° C. was also measured at both the edge and center of the cores. The dynamic stiffness at both the edge and the center of the core of the current invention varied only slightly, less than 125 percent, over the temperature range investigated. The core made according to U.S. Pat. No. 3,239,228 varied over 230 percent, whereas the cores made according to other

US 6,486,261 B1

31

conventional technology, had a dynamic stiffness that varied by greater than 130 percent, and typically by as much as 150 percent, over the same temperature range.

The percent of trans-conversion was also measured at both the center and edge of the core prepared according to the current invention, and for cores prepared according to the same four patents mentioned above, allowing a trans-gradient to be calculated. The core according to the current invention had a trans-gradient of about 45 percent from edge to center. Two of the cores prepared in accordance with U.S. Pat. Nos. 3,239,228 and 4,692,497 had a zero trans-gradient. A third core, prepared in accordance with U.S. Pat. No. 5,697,856, had only a slight trans-gradient, less than 18 percent from edge to center. A fourth core, prepared in accordance with U.S. Pat. No. 5,252,652, had a very large gradient, almost 65 percent, from edge to center.

Example 3

A Core Prepared From According to the Invention, Employing a Blend of Organosulfur and Inorganic Sulfide Cis-to-trans Catalyst

A core according to the present invention was created employing a blend of organosulfur and inorganic sulfide compounds as the cis-to-trans conversion catalyst. The resultant core properties clearly demonstrate the advantages of a golf ball core made according to the current invention (is compared to example cores constructed with conventional technology. The components and physical characteristics are presented in Table 4.

The compressive load is approximately half of the compressive load of three cores constructed in accordance with U.S. Pat. Nos. 5,697,856, 5,252,652, and 4,692,497, while at the same time retaining roughly the same, and in some cases a higher COR (resilience). The core made according to the current invention is soft, yet resilient (fast). The compressive load of the invention is greater than a fourth core constructed in accordance with U.S. Pat. No. 3,239,228, but has a significantly higher COR. The core constructed in accordance with U.S. Pat. No. 3,239,228 is very soft and very slow (low COR).

The percent change in dynamic stiffness from 0° C. to -50° C. was also measured at both the edge and center of the cores. The dynamic stiffness at both the edge and the center of the core of the current invention varied only slightly, less than 121 percent, over the temperature range investigated. The core made in accordance with U.S. Pat. No. 3,239,228 varied over 230 percent, whereas the cores made according to other conventional technology had a dynamic stiffness that varied by greater than 130 percent, and typically by as much as 150 percent, over the same temperature range.

The percent of trans-conversion was also measured at both the center and edge of the core prepared according to the current invention, and for cores prepared to the same four patents mentioned above, allowing a trans-gradient to be calculated. The core according to the current invention had a trans-gradient that about 44 percent from edge to center. For the core prepared according to the current invention, the pre- and post-cure trans-percentages was also measured to determine the effectiveness of that process. The percentage of polybutadiene converted to the trans-isomer ranged from almost 26 percent at the center to greater than 45 percent at the edge. Two of the cores prepared in accordance with U.S. Pat. Nos. 3,239,228 and 4,692,497 had a zero trans-gradient. A third core prepared in accordance with U.S. Pat. No. 5,697,856 had only a slight trans-gradient, less than 18 percent from edge to center. A fourth core, prepared in accordance with U.S. Pat. No. 5,252,652 had a very large gradient, almost 65 percent from edge to center.

32

Example 4

Comparison of a Conventional Dual Core Ball to Dual Core Ball Prepared According to the Invention

A dual core golf ball according to the present invention was created having a solid center, an intermediate layer surrounding the solid center, and a multilayer cover disposed concentrically around the intermediate layer. The components and physical characteristics are presented below in Table 5.

TABLE 5

Example 4: Dual Core	
<u>Center Composition</u>	
CARIFLEX BR1220	100
zinc diacrylate	20
dicumyl peroxide	2.5
zinc oxide	39
DTDS	0.75
<u>Center Properties</u>	
% trans Precure	1.5
% trans Postcure	40
load in lbs required (10.8% deflection)	109
<u>Mantle Composition</u>	
CB23	80
zinc diacrylate	38
VAROX 231 XL	0.42
DBDB-60	0.15
zinc oxide	6
polyisoprene	20
<u>Inner Cover Composition and Properties</u>	
Na SURLYN	50
Li SURLYN	50
Shore D hardness	68
thickness	0.03 in
<u>Outer Cover Composition and Properties</u>	
MDI polyurethane	
thickness	0.03 in

A solid center was constructed for the ball of the present invention. The center was created from CARIFLEX BR-1220 polybutadiene as the starting material, the only difference being replacing the VAROX 802-40KE-HP peroxide (conventional technology) with a DTDS cis-to-trans catalyst of the current invention and dicumyl peroxide. This substitution allows a portion of the polybutadiene material to be converted to the trans-configuration during the molding process. The resulting solid center had an outside diameter of approximately 1.15 inches. The polybutadiene reaction product prepared thereby had a trans-isomer content of 40 percent compared to the 1.5 percent trans-isomer of conventional balls. An intermediate layer, having outside diameter of approximately 1.56 inches, was constructed around the solid center to form a core. The outer layer is made of CB23 having a molecular weight of about 360,000 and a Mooney viscosity of about 51.

Examples 5-8

Comparison of Conventional Golf Balls with Those Prepared According to the Invention

A polybutadiene reaction product was prepared for two conventional prior art compositions (Examples 5-6) as well as one prepared according to the invention (Examples 7-8). The recipes for each composition can be seen in Table 6 below.

US 6,486,261 B1

33

TABLE 6

Reaction Product	Example 5 (phr)	Example 6 (phr)	Example 7 (phr)	Example 8 (phr)
CARIFLEX BR1220	100	100	100	100
zinc oxide	26.6	2.67	26.6	26.6
barium sulfate	—	31	—	—
zinc diacrylate	20	22.3	20	20
dicumyl peroxide	2	—	2	2
VAROX 802 40KE-HP ^a	—	0.89	—	—
polymeric sulfur	0	0	0.25	0
elemental sulfur	0	0	0	0.25
pre-cure trans-polybutadiene content	1.5%	1.5%	1.5%	1.5%
Golf Ball Core				
post-cure trans-polybutadiene content in reaction product	1.5%	1.5%	12%	12%
Atti Compression COR	53 n/a ^b	23 0.72	26 0.77	21 0.76

^aA di-(2-t-butylisopropylperoxy)-benzene peroxide commercially available from R.T. Vanderbilt of Norwalk, CT.

^bThe core of Example 5 was sufficiently rigid to crack during testing of the coefficient of restitution, indicating an undesirably low COR.

These constituents were mixed and molded, thereby converting a percentage of cis- to a trans-conformation, in a solid sphere sized like the core of a golf ball. Examples 7-8 illustrate the significant conversion of cis-polybutadiene to trans-polybutadiene when a sulfur cis-to-trans catalyst is present according to the invention compared to the lack of conversion in Examples 5-6 when no sulfur catalyst is present. Moreover, Examples 7-8 illustrate the improved coefficient of restitution with no significant change in compression that can be achieved with golf balls including the reaction product according to the invention.

The invention described and claimed herein is not to be limited in scope by the specific embodiments herein disclosed, since these embodiments are intended as illustrations of several aspects of the invention. Any equivalent embodiments are intended to be within the scope of this invention. Indeed, various modifications of the invention in addition to those shown and described herein will become apparent to those skilled in the art from the foregoing description. Such modifications are also intended to fall within the scope of the appended claims.

What is claimed is:

1. A golf ball comprising:

a center comprising a material formed from a conversion reaction of polybutadiene having a first amount of trans-isomer, a free radical source, and at least one cis-to-trans catalyst, wherein the material has a molecular weight of greater than about 200,000 and a resilience index of at least about 40; and

a cover layer comprising a polyurethane composition formed from a prepolymer having no greater than 7.5 percent by weight unreacted isocyanate groups.

2. The golf ball of claim 1, wherein the resilience index is greater than about 50.

3. The golf ball of claim 1, wherein the polyurethane composition comprises at least one isocyanate, at least one polyol, and at least one curing agent.

4. The golf ball of claim 3, wherein the isocyanate comprises 4,4'-diphenylmethane diisocyanate, polymeric 4,4'-diphenylmethane diisocyanate, carbodiimide-modified liquid 4,4'-diphenylmethane diisocyanate, 4,4'-dicyclohexylmethane diisocyanate, p-phenylene diisocyanate, toluene diisocyanate, isophoronediiisocyanate, p-methylxylene diisocyanate, m-methylxylene diisocyanate, o-methylxylene diisocyanate, or a mixture thereof.

34

5. The golf ball of claim 3, wherein the at least one polyol comprises a polyether polyol, hydroxy-terminated polybutadiene, polyester polyol, polycaprolactone polyol, polycarbonate polyol, or mixtures thereof.

6. The golf ball of claim 3, wherein the curing agent comprises a polyamine curing agent, a polyol curing agent, or a mixture thereof.

7. The golf ball of claim 6, wherein the curing agent is a polyamine curing agent.

8. The golf ball of claim 7, wherein the polyamine curing agent comprises 3,5-dimethylthio-2,4-toluenediamine, or an isomer thereof; 3,5-diethyltoluene-2,4-diamine, or an isomer thereof; 4,4'-bis-(sec-butylamino)-diphenylmethane; 1,4-bis-(sec-butylamino)-benzene, 4,4'-methylene-bis-(2-chloroaniline); 4,4'-methylene-bis-(3-chloro-2,6-diethylaniline); trimethylene glycol-di-p-aminobenzoate; polytetramethyleneoxide-di-p-aminobenzoate; N,N'-dialkylidiamino diphenyl methane; p,p'-methylene dianiline; phenylenediamine; 4,4'-methylene-bis-(2-chloroaniline); 4,4'-methylene-bis-(2,6-diethylaniline); 4,4'-diamino-3,3'-diethyl-5,5'-dimethyl diphenylmethane; 2,2',3,3'-tetrachloro diamino diphenylmethane; 4,4'-methylene-bis-(3-chloro-2,6-diethylaniline); or mixtures thereof.

9. The golf ball of claim 6, wherein the curing agent is a polyol curing agent.

10. The golf ball of claim 9, wherein the polyol curing agent comprises ethylene glycol; diethylene glycol; polyethylene glycol; propylene glycol; polypropylene glycol; lower molecular weight polytetramethylene ether glycol; 1,3-bis(2-hydroxyethoxy)benzene; 1,3-bis-[2-(2-hydroxyethoxy)ethoxy]benzene; 1,3-bis-[2-[2-(2-hydroxyethoxy)ethoxy]ethoxy]benzene; 1,4-butanediol; 1,5-pentanediol; 1,6-hexanediol; resorcinol-di-(β-hydroxyethyl)ether; hydroquinone-di-(β-hydroxyethyl) ether; trimethylol propane, or mixtures thereof.

11. The golf ball of claim 1, wherein the prepolymer has from about 2.5 percent up to 7.5 percent by weight unreacted isocyanate groups.

12. The golf ball of claim 1, wherein the cover layer has a thickness of less than about 0.05 inches.

13. The golf ball of claim 1, wherein the center has a Mooney viscosity from about 40 to about 80.

14. The golf ball of claim 13, wherein the Mooney viscosity from about 45 to about 60.

15. The golf ball of claim 1, wherein the polybutadiene has a vinyl-isomer content of less than about 2 percent by weight.

16. The golf ball of claim 1, wherein the polybutadiene has a cis-isomer content of at least about 95 percent by weight.

17. The golf ball of claim 1, wherein the center has an outer diameter of at least about 1.55 inches.

18. The golf ball of claim 1, wherein the polyurethane is thermoplastic or thermoset.

19. The golf ball of claim 1, wherein the reaction occurs at a temperature sufficient to form a polybutadiene reaction product having a second amount of trans-isomer greater than the first amount of trans-isomer.

20. The golf ball of claim 1, wherein the cis-to-trans catalyst further comprises at least one of an organosulfur compound, an inorganic sulfur compound, an aromatic organometallic compound, a metal-organosulfur compound, tellurium, selenium, elemental sulfur, a polymeric sulfur, or an aromatic organic compound.

21. The golf ball of claim 20, wherein the organosulfur component comprises at least one of 4,4'-diphenyl disulfide, 4,4'-ditolyl disulfide, or 2,2'-benzamido diphenyl disulfide.

22. The golf ball of claim 1, wherein the cis-to-trans catalyst is present in an amount from about 0.1 to 10 parts per hundred of polybutadiene.

23. The golf ball of claim 1, further comprising an intermediate layer between the center and the cover layer,

US 6,486,261 B1

35

wherein the intermediate layer comprises a material formed from a conversion reaction of polybutadiene having a first amount of trans-polybutadiene, a free radical source, and a cis-to-trans catalyst comprising at least one organosulfur component, wherein the intermediate layer has an outer diameter of at least about 1.58 inches, and wherein the center has an outer diameter of less than about 1.55 inches.

24. The golf ball of claim 1, wherein the cover comprises an inner cover layer and an outer cover layer, the inner cover layer disposed between the center and the outer cover layer.

25. The golf ball of claim 24, wherein at least one of the inner and outer cover layer has a thickness of less than about 0.05 inches.

26. The golf ball of claim 24, wherein the inner cover layer comprises an ionomer resin, a polyurethane, a polyetherester, a polyetheramide, a polyester, a dynamically vulcanized elastomer, a functionalized styrenebutadiene elastomer, a metallocene polymer nylon, acrylonitrile butadiene-styrene copolymer, or blends thereof.

27. The golf ball of claim 24, wherein the inner cover has an outer diameter of at least about 1.55 inches.

28. The golf ball of claim 24, wherein the inner cover has an outer diameter of about 1.58 to about 1.64 inches.

29. A golf ball comprising:

a center comprising a material formed from a conversion reaction of polybutadiene having a first amount of trans-isomer, a free radical source, and at least one cis-to-trans catalyst, wherein the material has a molecular weight of greater than about 300,000 and a resilience index of at least about 40;

a outer core layer surrounding the center, the outer core layer having an outer diameter of at least about 1.51 inches;

an inner cover layer surrounding the outer core layer; and an outer cover layer disposed about the inner cover layer, the outer cover layer comprising a polyurethane composition formed from a prepolymer having less than 7.5 percent by weight unreacted isocyanate groups.

30. The golf ball of claim 29, wherein the polyurethane is thermoplastic or thermoset.

31. The golf ball of claim 29, wherein the resilience index is greater than about 50.

32. The golf ball of claim 29, wherein the polyurethane composition comprises an isocyanate, at least one polyol, and at least one curing agent.

33. The golf ball of claim 32, wherein the isocyanate comprises 4,4'-diphenylmethane diisocyanate, polymeric 4,4'-diphenylmethane diisocyanate, carbodiimide-modified liquid 4,4'-diphenylmethane diisocyanate, 4,4'-dicyclohexylmethane diisocyanate, p-phenylene diisocyanate, toluene diisocyanate, isophoronediiisocyanate, p-methylxylene diisocyanate, m-methylxylene diisocyanate, o-methylxylene diisocyanate, or a mixture thereof.

34. The golf ball of claim 32, wherein the at least one polyol comprises a polyether polyol, hydroxy-terminated polybutadiene, polyester polyol, polycaprolactone polyol, polycarbonate polyol, or mixtures thereof.

35. The golf ball of claim 32, wherein the curing agent comprises a polyamine curing agent, a polyol curing agent, or a mixture thereof.

36. The golf ball of claim 35, wherein the curing agent is a polyamine curing agent comprising 3,5-dimethylthio-2,4-toluenediamine, or an isomer thereof; 3,5-diethyltoluene-2,4-diamine, or an and isomer thereof; 4,4'-bis-(sec-

36

butylamino)-diphenylmethane; 1,4-bis-(sec-butylamino)-benzene, 4,4'-methylene-bis-(2-chloroaniline); 4,4'-methylene-bis-(3-chloro-2,6-diethylaniline); trimethylene glycol-di-p-aminobenzoate; polytetramethyleneoxide-di-p-aminobenzoate; N,N'-dialkyldiamino diphenyl methane; p,p'-methylene dianiline; m-phenylenediamine; 4,4'-methylene-bis-(2-chloroaniline); 4'-methylene-bis-(2,6-diethylaniline); 4,4'-diamino-3,3'-diethyl-5,5'-dimethyl diphenylmethane; 2,2',3,3'-tetrachloro diamino diphenylmethane; 4,4'-methylene-bis-(3-chloro-2,6-diethylaniline); or mixtures thereof.

37. The golf ball of claim 35, wherein the curing agent is a polyol curing agent comprising ethylene glycol; diethylene glycol; polyethylene glycol; propylene glycol; polypropylene glycol; lower molecular weight polytetramethylene ether glycol; 1,3-bis(2-hydroxyethoxy)benzene; 1,3-bis-[2-(2-hydroxyethoxy)ethoxy]benzene; 1,3-bis-[2-(2-hydroxyethoxy)ethoxy]ethoxy benzene; 1,4-butanediol; 1,5-pentanediol; 1,6-hexanediol; resorcinol-di(-hydroxyethyl)ether; hydroquinone-di(-hydroxyethyl)ether; trimethylol propane, or mixtures thereof.

38. The golf ball of claim 29, wherein the prepolymer has from about 2.5 percent up to 7.5 percent by weight unreacted isocyanate groups.

39. The golf ball of claim 29, wherein at least one of the inner and outer cover layers has a thickness of less than about 0.05 inches.

40. The golf ball of claim 29, wherein the center has a Mooney viscosity of from about 40 to about 80.

41. The golf ball of claim 29, wherein the polybutadiene has a vinyl-isomer content of less than about 2 percent by weight.

42. The golf ball of claim 29, wherein the polybutadiene has a cis-isomer content of at least about 95 percent by weight.

43. The golf ball of claim 29, wherein the center has an outer diameter of no greater than about 1.55 inches.

44. The golf ball of claim 29, wherein the reaction occurs at a temperature sufficient to form a polybutadiene reaction product having a second amount of trans-isomer greater than the first amount of trans-isomer.

45. The golf ball of claim 29, wherein the cis-to-trans catalyst further comprises at least one of an organosulfur compound, an inorganic sulfur compound, an aromatic organometallic compound, a metal-organosulfur compound, tellurium, selenium, elemental sulfur, a polymeric sulfur, or an aromatic organic compound.

46. The golf ball of claim 45, wherein the organosulfur component comprises at least one of 4,4'-diphenyl disulfide, 4,4'-ditolyl disulfide, or 2,2'-benzamido diphenyl disulfide.

47. The golf ball of claim 29, wherein the cis-to-trans catalyst is present in an amount from about 0.1 to 10 parts per hundred of polybutadiene.

48. The golf ball of claim 29, wherein the inner cover layer comprises an ionomer resin, a polyurethane, a polyetherester, a polyetheramide, a polyester, a dynamically vulcanized elastomer, a functionalized styrenebutadiene elastomer, a metallocene polymer, nylon, acrylonitrile butadiene-styrene copolymer or blends thereof.

49. The golf ball of claim 29, wherein the inner cover has an outer diameter of at least about 1.55 inches.

50. The golf ball of claim 49, wherein the inner cover has an outer diameter of about 1.58 to about 1.64 inches.

* * * * *

EXHIBIT 18

United States Patent [19]

Kakiuchi et al.

[11] Patent Number: **4,683,257**[45] Date of Patent: **Jul. 28, 1987**

[54] RUBBER COMPOSITIONS FOR SOLID GOLF BALLS

[75] Inventors: Shinichi Kakiuchi, Kodaira; Tasuku Saito; Seisuke Tomita, both of Tokorozawa, all of Japan

[73] Assignee: Bridgestone Corporation, Tokyo, Japan

[21] Appl. No.: 872,879

[22] Filed: Jun. 11, 1986

[30] Foreign Application Priority Data

Jun. 12, 1985 [JP] Japan 60-125968

[51] Int. Cl.⁴ A63B 37/00; A63B 37/06; C08K 3/20; C08L 9/00

[52] U.S. CL 524/432; 273/218; 524/908; 525/193; 525/236

[58] Field of Search 525/193, 236; 524/908, 524/432; 273/218

[56] References Cited

U.S. PATENT DOCUMENTS

4,483,537 11/1984 Hanada et al. 273/218
 4,546,980 10/1985 Gendreau et al. 524/908
 4,561,657 12/1985 Tominaga et al. 273/218

Primary Examiner—Allan M. Lieberman
 Attorney, Agent, or Firm—Birch, Stewart, Kolasch & Birch

[57] ABSTRACT

Solid golf balls are formed from a molding composition comprising (1) a polybutadiene blend of (A) a polybutadiene synthesized using a nickel and/or cobalt base catalyst and having a Mooney viscosity of 70 to 100 with (B) less than 50 parts by weight of a polybutadiene synthesized using a lanthanide rare earth element base catalyst and having a Mooney viscosity of 30 to 90 or (C) 20 to 80 parts by weight of a polybutadiene synthesized using a nickel and/or cobalt base catalyst and having a Mooney viscosity of 20 to 50, the polybutadienes containing at least 40% of cis-1,4 bond, (2) a cross-linking agent such as acrylic and methacrylic acid, (3) an inorganic filler, and (4) an organic peroxide.

5 Claims, No Drawings

4,683,257

1

RUBBER COMPOSITIONS FOR SOLID GOLF BALLS

BACKGROUND OF THE INVENTION

This invention relates to a rubber composition for use in solid golf balls.

Solid golf balls are well known as including one-, two-, and three-piece golf balls. Most solid golf balls are formed of rubber compositions. Typical rubber compositions used in the forming of solid golf balls are comprised of polybutadienes which are synthesized using nickel or cobalt base catalysts and have at least 40% of cis-1,4 bonds and a Mooney viscosity $ML_{1+4}(100^\circ \text{C.})$ of up to 60 because of their milling characteristics and processability on an extruder.

It is also known that polybutadienes synthesized using lanthanide rare earth element base catalysts would find a potential use as a rubber component of solid golf ball-forming rubber compositions.

The former polybutadienes synthesized using nickel or cobalt base catalysts and having at least 40% of cis-1,4 bond and a Mooney viscosity of up to 60 provide satisfactory workability, but leave great room for improvement in resilience property. The latter polybutadienes synthesized using lanthanide rare earth element base catalysts have never been used in commercial products because of many problems in actual applications.

SUMMARY OF THE INVENTION

A primary object of the present invention is to provide a novel and improved solid golf ball-forming rubber composition which allows for the production of a solid golf ball having high resilience and improved initial speed.

The present invention is directed to a rubber composition for use in forming one-piece solid golf balls or the core of multiple solid golf balls including two- and three-piece solid golf balls, comprising (1) a polybutadiene having at least 40% of cis-1,4 bonds, (2) an unsaturated carboxylic acid and/or a salt thereof capable of producing crosslinking in the polybutadiene, (3) an inorganic filler, and (4) an organic peroxide. According to the feature of the invention, the polybutadiene (1) comprises 100 parts by weight of a blend of

(A) a polybutadiene synthesized in the presence of a nickel and/or cobalt base catalyst and having a Mooney viscosity $ML_{1+4}(100^\circ \text{C.})$ of 70 to 100 and

(B) less than 50 parts by weight of a polybutadiene synthesized in the presence of a lanthanide rare earth element base catalyst and having a Mooney viscosity $ML_{1+4}(100^\circ \text{C.})$ of 30 to 90 or

(C) 20 to 80 parts by weight of a polybutadiene synthesized in the presence of a nickel and/or cobalt base catalyst and having a Mooney viscosity $ML_{1+4}(100^\circ \text{C.})$ of 20 to 50.

In the course of development of a solid golf ball-forming rubber composition which has the advantages of improving the initial speed of the resulting solid golf ball and ease of working, we have found that a solid golf ball-forming rubber composition comprising as a sole rubber component (A) a polybutadiene synthesized in the presence of a nickel and/or cobalt base catalyst and having a Mooney viscosity $ML_{1+4}(100^\circ \text{C.})$ of 70 to 100 is fully effective in improving the initial speed of a solid golf ball. The rubber composition containing polybutadiene (A), however, has very poor milling characteris-

2

tics on roll mills and very poor workability on extruder and molding equipment to meet commercial operational requirements. Unexpectedly, we have found that when (A) a polybutadiene synthesized in the presence of a nickel and/or cobalt base catalyst and having a Mooney viscosity of 70 to 100 is used in admixture with (B) a polybutadiene synthesized in the presence of a lanthanide rare earth element base catalyst in a certain proportion or with (C) a polybutadiene synthesized in the presence of a nickel and/or cobalt base catalyst and having a Mooney viscosity of 20 to 50 in a certain proportion, the resulting blend can avoid the reduced workability on kneaders and roll mills due to inferior knitting performance of mixed compounds encountered with the use of polybutadiene (A) alone. More particularly, although (A) a polybutadiene synthesized in the presence of a nickel and/or cobalt base catalyst and having a Mooney viscosity of 70 to 100 cannot be handled with the existing equipment because of worst roll workability during extrusion, the aforementioned polybutadiene blends of (A) and (B) or (C) are compatible with the existing equipment and have improved workability, resulting in increased productivity. Moreover, solid golf balls having cores formed of the polybutadiene blends of (A) and (B) or (C) show an increased initial speed which in turn, increases the flying distance of ball.

The above and other objects, features, and advantages of the present invention will be more apparent from the following description.

DETAILED DESCRIPTION OF THE INVENTION

As described above, the rubber composition for forming solid golf balls according to the present invention comprises (1) a polybutadiene having at least 40% of cis-1,4 bond, (2) an unsaturated carboxylic acid and/or a salt thereof capable of producing crosslinking in the polybutadiene, (3) an inorganic filler, and (4) an organic peroxide.

The polybutadiene (1) should be comprised of a blend of (A) a polybutadiene synthesized in the presence of a nickel and/or cobalt base catalyst and having a Mooney viscosity $ML_{1+4}(100^\circ \text{C.})$ of 70 to 100 and (B) a polybutadiene synthesized in the presence of a lanthanide rare earth element base catalyst and having a Mooney viscosity $ML_{1+4}(100^\circ \text{C.})$ of 30 to 90 or (C) a polybutadiene synthesized in the presence of a nickel and/or cobalt base catalyst and having a Mooney viscosity $ML_{1+4}(100^\circ \text{C.})$ of 20 to 50.

Polybutadienes (A) used herein should preferably contain at least 40%, especially at least 80% of cis-1,4 bonds and have a Mooney viscosity of 70 to 100.

Polybutadienes (A) may be prepared by polymerizing butadiene monomer in the presence of a nickel base catalyst, for example, one-component catalysts such as nickel on diatomaceous earth, two-component catalysts such as Raney nickel/titanium tetrachloride, and three-component catalysts such as nickel compound/organometal/trifluoroborate etherate. Examples of the nickel compounds used herein include reduced nickel on carrier, Raney nickel, nickel oxides, nickel carboxylate, and organic nickel complex salts. Examples of the organometals include trialkyl aluminums such as triethyl aluminum, tri-n-propyl aluminum, triisobutyl aluminum, and tri-n-hexyl aluminum; alkyl lithiums such as n-butyl lithium, sec.-butyl lithium, tert.-butyl lithium,

4,683,257

3

and 1,4-butane dilithium; dialkyl zincs such as diethyl zinc and dibutyl zinc, and the like. Polymerization of butadiene in the presence of these catalysts is generally carried out by continuously charging a reactor with butadiene monomer along with a solvent such as aliphatic, aromatic and cycloaliphatic hydrocarbon solvents, and a catalyst such as nickel octanoate and triethyl aluminum and controlling the reaction temperature in the range of 5° to 60° C. and the reaction pressure in the range from one to several atmospheres, namely from atmospheric pressure to about 70 atmospheres such that a product having a predetermined Mooney viscosity may be obtained.

Cobalt base catalysts are also useful in the preparation of polybutadienes (A). Examples of the cobalt base catalysts used herein include elemental cobalt and cobalt compounds, for example, Raney cobalt, cobalt chloride, cobalt bromide, cobalt iodide, cobalt oxide, cobalt sulfate, cobalt carbonate, cobalt phosphate, cobalt phthalate, cobalt carbonyl, cobalt acetylacetonate, cobalt diethyldithiocarbamate, cobalt anilinium nitrite, cobalt dinitrosyl chloride, etc. Particularly, combinations of these cobalt compounds with a dialkyl aluminum monochloride (e.g., diethyl aluminum monochloride and diisobutyl aluminum monochloride), a trialkyl aluminum (e.g., triethyl aluminum, tri-n-propyl aluminum, triisobutyl aluminum, and tri-n-hexyl aluminum), and aluminum chloride or with an alkyl aluminum sesquichloride (e.g., ethyl aluminum sesquichloride) and aluminum chloride are preferred catalysts for use in the preparation of polymers of cis-1,4 bond type. The process of preparing polybutadienes using the cobalt base catalysts is similar to that with the nickel base catalysts.

Polybutadienes (B) which are combined with polybutadienes (A) into the blends according to the present invention are those polybutadienes synthesized in the presence of a lanthanide rare earth element base catalyst, containing at least 40%, desirably at least 80% of cis-1,4 bonds, and having a Mooney viscosity $ML_{1+4}(100^\circ \text{C.})$ of 30 to 90.

Polybutadienes (B) may be prepared by polymerizing butadiene monomer in the presence of catalysts comprising a lanthanide rare earth element compound (to be simply referred to as a lanthanide compound, hereinafter), an organoaluminum compound, a Lewis base, and optionally, a Lewis acid. The lanthanide compounds used herein include halides, carboxylates, alcoholates, thioalcoholates, and amides of metals having atomic numbers of 57 to 71. The organoaluminum compounds used herein may be those having the general formula: $AlR^1R^2R^3$ wherein R^1 , R^2 , and R^3 are independently selected from hydrogen and hydrocarbon residues having 1 to 8 carbon atoms, and R^1 , R^2 , and R^3 may be the same or different.

The Lewis bases serve to convert the lanthanide compounds into complexes, and acetylacetone and ketone alcohols and the like may be used for this purpose.

The Lewis acids used include aluminum halides of the general formula: $AlX_nR_{(3-n)}$ wherein X is a halogen, R is a hydrocarbon residue (for example, hydrocarbon residues having 1 to about 20 carbon atoms such as alkyl, aryl, and aralkyl radicals), and n is equal to 1, 1.5, 2, or 3, and other metal halides such as silicon tetrachloride, tin tetrachloride, and titanium tetrachloride.

When butadiene is polymerized in the presence of the above-mentioned catalyst, the molar ratio of butadiene to lanthanide compound preferably ranges from 5×10^2 to 5×10^6 , especially from 10^3 to 10^5 , and the molar ratio

4

of $AlR^1R^2R^3$ to lanthanide compound preferably ranges from 5 to 500, especially from 10 to 300. The preferred proportion of Lewis base to lanthanide compound is at least 0.5, and especially ranges from 1 to 20 in molar ratio. When a Lewis acid is used, the preferred proportion of halide in the Lewis acid to lanthanide compound ranges from 1 to 10, especially from 1.5 to 5 in molar ratio.

In the polymerization of butadiene, the lanthanide compound base catalysts may be used as solution in a suitable solvent such as n-hexane, cyclohexane, n-heptane, toluene, xylene, benzene, etc. or carried on suitable carriers such as silica, magnesia, and magnesium chloride.

Polymerization of butadiene may be carried out in a solvent such as n-hexane, cyclohexane, n-heptane, toluene, xylene, benzene, etc., or bulk polymerization without a solvent may also be employed. The polymerization temperature typically ranges from -30° C. to 150° C., preferably from 10° C. to 80° C. The polymerization pressure may vary depending on other conditions.

When a blend of components (A) and (B) is used as the polybutadiene rubber composition (1) in the solid golf ball-forming rubber compositions of the present invention, components (A) and (B) are preferably blended such that more than 50 parts by weight to 90 parts by weight of (A) is present per 100 parts by weight of (A) and (B) combined. The most preferred proportion is 60 to 90 parts by weight of (A) and 40 to 10 parts by weight of (B) per 100 parts of (A) and (B) combined. Blends containing up to 50 parts by weight of (A) result in solid golf balls having less satisfactory resilience and hence, little increased initial speed whereas contents of more than 90 parts by weight of (A) in the blends render the resulting rubber compositions too hard in the necessary working or processing operations such as milling.

When a blend of components (A) and (C) is used as the polybutadiene rubber composition (1) in the solid golf ball-forming rubber compositions of the present invention, component (C) used is a polybutadiene which is prepared by polymerizing butadiene in the presence of a nickel and/or cobalt base catalyst as in the preparation of component (A) and contains at least 40%, preferably at least 80% of cis-1,4 bond and a Mooney viscosity of 20 to 50. The nickel and cobalt base catalysts used herein may be selected from the same catalysts as used in the synthesis of component (A). Polymerization may be effected under similar conditions as in the synthesis of component (A) except that the resulting polybutadiene may have a Mooney viscosity of 20 to 50.

Component (C) is preferably blended such that 80 to 20 parts by weight of (A) and 20 to 80 parts by weight of (C) are present per 100 parts by weight of (A) and (C) combined. The most preferred proportion is 70 to 30 parts by weight of (A) and 30 to 70 parts by weight of (C) per 100 parts of (A) and (C) combined. Blends containing less than 20% by weight of (A) result in solid golf balls having less satisfactory resilience and hence, little increased initial speed whereas contents of more than 80 parts by weight of (A) in the blends render the resulting rubber compositions too hard and hence, difficult to process such as by milling.

One-piece solid golf balls or solid cores of multiple solid golf balls including two- and three-piece solid golf balls are formed from the rubber compositions of the present invention by crosslinking and curing the polybutadiene blend therein with an unsaturated carboxylic

acid and/or a salt thereof. To this end, the composition is rendered crosslinkable by incorporating the unsaturated carboxylic acid or salt and other ingredients such as inorganic filler and organic peroxide in suitable proportions. Preferred examples of the unsaturated carboxylic acids and salts which produce crosslinking in the polybutadienes include acrylic acid, methacrylic acid, and zinc salts thereof. The inorganic filler may be, for example, zinc oxide, barium sulfate, and silica. The organic peroxide may be, for example, dicumyl peroxide, 1,1-di-*t*-butylperoxy-3,3,5-trimethylcyclohexane, 2,5-dimethyl-2,5-di-*t*-butylperoxyhexane, and 1,3-bis-*t*-butylperoxy-isopropylbenzene. Illustrative examples of the rubber compositions include compositions comprising 100 parts by weight of the abovementioned polybutadiene blend, 10 to 60 parts by weight of an unsaturated carboxylic acid or a metal salt thereof, 10 to 70 parts by weight of an inorganic filler, and 0.1 to 6 parts by weight of a peroxide, and more preferably those compositions comprising 100 parts by weight of the abovementioned polybutadiene blend, 10 to 30 parts by weight of acrylic and/or methacrylic acid, 10 to 70 parts by weight of an inorganic filler such as zinc oxide, and 0.5 to 6 parts by weight of an organic peroxide; and those compositions comprising 100 parts by weight of the above-mentioned polybutadiene blend, 20 to 60 parts by weight of a metal salt of unsaturated carboxylic acid such as zinc acrylate and zinc methacrylate, 10 to 60 parts by weight of an inorganic filler (extending filler) such as zinc oxide, and 0.1 to 5 parts by weight of an organic peroxide. Preferred solid golf balls or solid cores may be obtained by heat curing these compositions although the present invention is not limited to them.

The cover that envelops the solid core formed from the rubber composition of the present invention to complete a multiple solid golf ball, typically a two- or three-piece solid golf ball may advantageously be formed from an ionomer resin base composition, for example, an ionomer resin in admixture with an inorganic filler such as titanium dioxide, zinc oxide, zinc stearate, magnesium stearate, etc. The preferred ionomer resins are those polymers obtained by polymerizing a monoolefin with one or more members selected from unsaturated mono- and dicarboxylic acids having 3 to 8 carbon atoms and esters thereof and having a bridging metal bond attached thereto. The cover may preferably have a thickness in the range from 0.5 to 2.7 mm although the exact thickness may be properly selected depending on the desired performance.

The golf balls may be fabricated so as to meet the ordinary standard specifications with respect to overall weight and size.

In forming solid cores or balls from the rubber compositions of the present invention, the cores or balls may be molded in a conventional manner, for example, by milling the above-mentioned materials of the rubber composition on a conventional mill such as a Banbury mixer or roll mill, compression or injection molding the composition in a mold having a cavity corresponding to the core or ball, and heating the molded product. The temperature used in curing purposes may be 120° to 180° C. when the rubber composition contains dicumyl peroxide as the peroxide. The method of covering the solid core with a cover is not particularly limited. One method is by placing the solid core in a pair of cover halves preformed in semispherical shape and thermoforming them into an integral ball. Alternatively, the

cover composition may be injection molded over the solid core to form a core-cover integrated ball.

The rubber compositions of the present invention are rubber blends wherein (A) a polybutadiene synthesized in the presence of a nickel and/or cobalt base catalyst and having a Mooney viscosity of 70 to 100 is combined with (B) a polybutadiene synthesized in the presence of a lanthanide rare earth element base catalyst and having a Mooney viscosity of 30 to 90 or (C) a polybutadiene synthesized in the presence of a nickel and/or cobalt base catalyst and having a Mooney viscosity of 20 to 50, they exhibit improved workability on kneaders and roll mills due to knitting performance of mixed compounds. In addition to these processing advantages, they are also effective in improving the initial speed of solid golf balls having cores formed therefrom.

Examples of the present invention are given below by way of illustration and not by way of limitation.

EXAMPLES 1-6, COMPARATIVE EXAMPLES
1-4

Using various polybutadienes having the Mooney viscosity and cis-1,4 bond content reported in Tables 1 and 2, a series of rubber compositions consisting of 100 parts by weight of polybutadiene blend (total), 32 parts by weight of zinc acrylate, 17 parts by weight of zinc oxide, and 1.0 part by weight of dicumyl peroxide were kneaded by means of a Banbury mixer and a roll mill and then compression molded at 150° C. for 40 minutes into integral cores for the large size golf ball.

Thereafter, cover materials shown in Tables 1 and 2 are injection molded around the above-molded solid cores, yielding two-piece golf balls having physical properties as shown in Tables 1 and 2.

Table 1 contains the data of golf balls obtained using the core-forming rubber compositions according to the present invention (Examples). Table 2 contains those of golf balls prepared as comparative examples.

TABLE 1

	Examples				
	1	2	3	4	5
Solid core					
Composition, parts by weight					
Polybutadiene 1*	80	65	70	55	50
Polybutadiene 2	20	35	30	45	0
Polybutadiene 3	0	0	0	0	50
Polybutadiene 4	0	0	0	0	0
Zinc acrylate	32	32	32	32	32
Zinc oxide	17	17	17	17	17
Dicumyl peroxide	1.0	1.0	1.0	1.0	1.0
Mooney viscosity					
Polybutadiene 1	90	90	75	75	90
Polybutadiene 2	45	45	60	60	—
Polybutadiene 3	—	—	—	—	28
Polybutadiene 4	—	—	—	—	35
Cis-1,4 bond content, %					
Polybutadiene 1	96	96	95	95	96
Polybutadiene 2	93	93	94	94	—
Polybutadiene 3	—	—	—	—	94
Polybutadiene 4	—	—	—	—	—
Weight, grams	34.2	34.3	34.2	34.2	34.3
Hardness (100 kg distortion), mm	2.8	2.8	2.9	2.9	2.9
Cover					
Composition, parts by weight					
Ionomer*2	100	100	100	100	100
Titanium dioxide	2	2	2	2	2
Thickness, mm	2.2	2.2	2.2	2.2	2.2
Ball physical properties					

4,683,257

7

8

TABLE 1-continued

	Examples					
	1	2	3	4	5	6
Weight, grams	45.5	45.5	45.5	45.4	45.5	45.4
Hardness (100 kg distortion), mm	2.3	2.3	2.4	2.4	2.4	2.4
Initial speed ^{*3} , m/sec.	65.9	65.8	65.8	65.7	65.9	65.8

Note:

^{*1}Polybutadiene 1: prepared using an Ni base catalyst in the form of nickel octanoate/triethyl aluminum/trifluoroborate.

Polybutadiene 2: prepared using an Nd base catalyst in the form of neodymium octanoate/acetylacetonate/triethyl aluminum/diethyl aluminum chloride.

Polybutadiene 3: prepared using a Co base catalyst in the form of cobalt octanoate/diethyl aluminum chloride/triethyl aluminum.

Polybutadiene 4: prepared using an Ni base catalyst in the form of nickel octanoate/triethyl aluminum/trifluoroborate.

Polybutadiene 5: prepared using an Li base catalyst in the form of n-butyl lithium

^{*2}Trademark Surlyn 1706, manufactured by duPont

^{*3}Initial speed is measured by hitting a ball in a T/T machine (a swing robot manufactured by True Temper Co.) with No. 1 wood club at a club head speed of 45 m/sec.

TABLE 2

	Comparative Examples			
	1	2	3	4
<u>Solid core</u>				
<u>Composition, parts by weight</u>				
Polybutadiene 1 ^{*1}	100	0	0	0
Polybutadiene 2	0	0	100	0
Polybutadiene 3	0	100	0	0
Polybutadiene 5	0	0	0	100
Zinc acrylate	32	32	32	32
Zinc oxide	17	17	17	17
Dicumyl peroxide	1.0	1.0	1.0	1.0
<u>Mooney viscosity</u>				
Polybutadiene 1	44	—	—	—
Polybutadiene 2	—	—	45	—
Polybutadiene 3	—	44	—	—
Polybutadiene 5	—	—	—	72
<u>Cis-1,4 bond content, %</u>				
Polybutadiene 1	96	—	—	—
Polybutadiene 2	—	—	93	—
Polybutadiene 3	—	94	—	—
Polybutadiene 5	—	—	—	45
Weight, grams	34.4	34.4	34.3	34.3
Hardness (100 kg distortion), mm	2.9	2.8	2.7	2.9
<u>Cover</u>				
<u>Composition, parts by weight</u>				
Ionomer ^{*2}	100	100	100	100
Titanium dioxide	2	2	2	2
Thickness, mm	2.2	2.2	2.2	2.2
<u>Ball physical properties</u>				
Weight, grams	45.6	45.5	45.4	45.5
Hardness (100 kg distortion), mm	2.4	2.3	2.3	2.4
Initial speed ^{*3} , m/sec.	64.8	64.6	65.2	64.3

Note:

^{*1}Polybutadiene 1: prepared using an Ni base catalyst in the form of nickel octanoate/triethyl aluminum/trifluoroborate.

Polybutadiene 2: prepared using an Nd base catalyst in the form of neodymium octanoate/acetylacetonate/triethyl aluminum/diethyl aluminum chloride.

Polybutadiene 3: prepared using a Co base catalyst in the form of cobalt octanoate/diethyl aluminum chloride/triethyl aluminum.

Polybutadiene 4: prepared using an Ni base catalyst in the form of nickel octanoate/triethyl aluminum/trifluoroborate.

Polybutadiene 5: prepared using an Li base catalyst in the form of n-butyl lithium

^{*2}Trademark Surlyn 1706, manufactured by duPont

^{*3}Initial speed is measured by hitting a ball in a T/T machine (a swing robot manufactured by True Temper Co.) with No. 1 wood club at a club head speed of 45 m/sec.

As seen from the data in Tables 1 and 2, the solid golf balls (Examples) using the core-forming rubber compositions of the present invention are improved in resilience, and hence, increased in initial speed over the solid golf balls using the prior art core-forming rubber compositions.

EXAMPLE 7 AND COMPARATIVE EXAMPLE 5

Small size one-piece golf balls were prepared by milling the individual ingredients as shown in Table 3 in a Banbury mixer and a roll mill, and compression molding the milled compound at 150° C. for 40 minutes. The balls were determined for the same properties by the same procedure as in the preceding examples. The results are reported in Table 3.

TABLE 3

	Example 7	Comparative Example 5
<u>Composition, parts by weight</u>		
Polybutadiene 1 ^{*1}	80	100
Polybutadiene 2	20	0
Methacrylic acid	22	22
Zinc oxide	26	26
Barium sulfate	18	18
Dicumyl peroxide	2.0	2.0
<u>Mooney viscosity</u>		
Polybutadiene 1	90	44
Polybutadiene 2	45	—
<u>Cis-1,4 bond content, %</u>		
Polybutadiene 1	96	96
Polybutadiene 2	93	—
<u>Ball physical properties</u>		
Weight, grams	45.5	45.6
Hardness (100 kg distortion), mm	2.3	2.4
Initial speed ^{*3} , m/sec.	64.9	64.0

^{*1}, ^{*3}See the footnotes of Tables 1 and 2

We claim:

1. A rubber composition, for use in forming one-piece golf balls or the core of multiple solid golf balls, comprising

(1) a polybutadiene having at least 10% of cis-1,4 bond,

(2) an unsaturated carboxylic acid and/or a salt thereof capable of producing crosslinking in the polybutadiene,

(3) an inorganic filler, and

(4) an organic peroxide,

wherein said polybutadiene consists essentially of a blend of

(A) a polybutadiene synthesized in the presence of a nickel and/or cobalt base catalyst and having a Mooney viscosity ML₁₊₄(100° C.) or 70 to 100 and

(B) a polybutadiene synthesized in the presence of a lanthanide rare earth element base catalyst and having a Mooney viscosity ML₁₊₄(100° C.) or 30 to 90, and

wherein said components (A) and (B) are blended such that more than 50 parts by weight to 90 parts by weight of said components (A) and less than 50 parts by weight to 10 parts by weight of said component (B) are present per 100 parts by weight of said blended components (A) and (B);

or wherein said polybutadiene consists essentially of a blend of

(A) a polybutadiene synthesized in the presence of a nickel and/or cobalt base catalyst and having a Mooney viscosity ML₁₊₄(100° C.) or 70 to 100 and

(C) a polybutadiene synthesized in the presence of a nickel and/or cobalt base catalyst and having a Mooney viscosity ML₁₊₄(100° C.) of 20 to 50, and

4,683,257

9

wherein said components (A) and (C) are blended such that 80 to 20 parts by weight of said component (A) and 20 to 80 parts by weight of said component (C) are present per 100 parts by weight of said blended components (A) and (C).

2. The composition of claim 1 wherein said polybutadiene is a blend of 60 to 90 parts by weight of (A) and 40 to 10 parts by weight of (B).

3. The composition of claim 1 wherein said polybutadiene is a blend of 70 to 30 parts by weight of (A) and 30 to 70 parts by weight of (C).

4. The rubber composition according to claim 1, which comprises 100 parts by weight of said polybuta-

10

diene blend, 10 to 60 parts by weight of said unsaturated carboxylic acid or a metal salt thereof, and 0.1 to 6 parts by weight of said peroxide.

5. The rubber composition according to claim 1, which comprises 100 parts by weight of said polybutadiene blend, 10 to 30 parts by weight of said unsaturated carboxylic acid wherein said unsaturated carboxylic acid is acrylic and/or methacrylic acid or a metal salt thereof, 10 to 70 parts by weight of said inorganic filler wherein said filler is zinc oxide, and 0.5 to 6 parts by weight of said organic peroxide.

* * * * *

15

20

25

30

35

40

45

50

55

60

65

EXHIBIT 19



US005252652A

United States Patent [19][11] **Patent Number:** 5,252,652

Egashira et al.

[45] **Date of Patent:** Oct. 12, 1993[54] **SOLID GOLF BALL**

[75] **Inventors:** Yoshinori Egashira, Saitama;
Kazuyuki Takahashi, Yokohama;
Seisuke Tomita, Tokorozawa, all of
Japan

[73] **Assignee:** Bridgestone Corporation, Tokyo,
Japan

[21] **Appl. No.:** 521,618[22] **Filed:** May 10, 1990[30] **Foreign Application Priority Data**

Nov. 5, 1989 [JP] Japan 1-118460

[51] **Int. Cl.³** C08K 5/09; C08K 5/36;
A63B 37/00

[52] **U.S. Cl.** 524/392; 524/289;
524/382; 524/908; 273/218

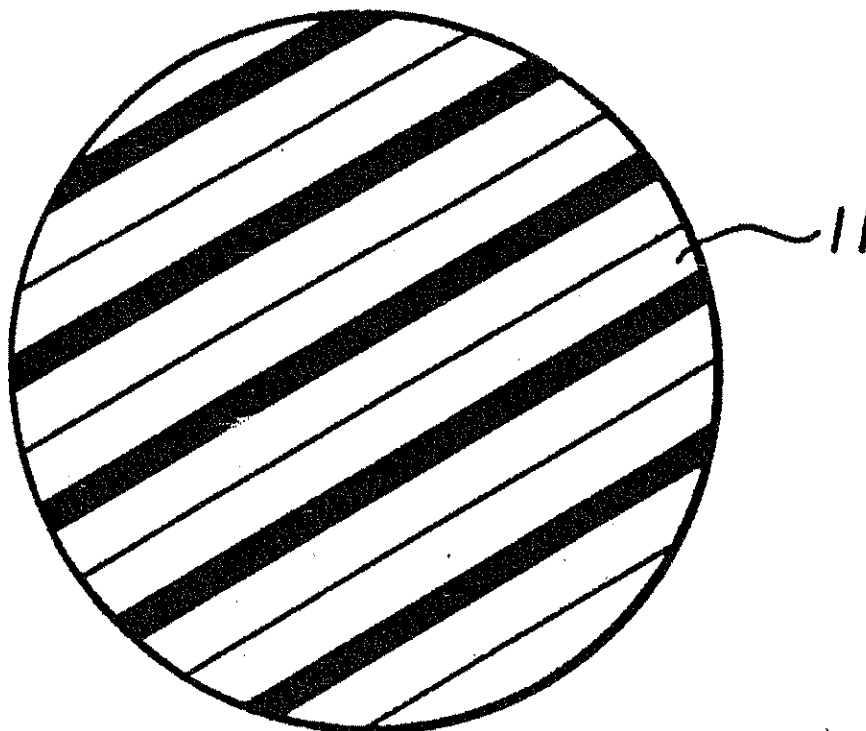
[58] **Field of Search** 524/908, 289, 382, 392[56] **References Cited****U.S. PATENT DOCUMENTS**

2,378,519 6/1945 Vincent 524/392
2,467,789 4/1949 Verbanc et al. 524/382

2,543,845 3/1951 Fryling 524/392
3,175,992 3/1965 Anderson, Jr. 524/392
3,804,421 4/1974 Alex et al. 293/218
3,923,719 12/1975 Gattuso 524/392
4,076,255 2/1978 Moore et al. 273/218
4,129,538 12/1978 Kaplan et al. 524/392
4,398,000 8/1983 Kataoka et al. 523/206
4,556,220 12/1985 Tomina et al. 524/908
4,595,721 6/1986 Devaux et al. 524/392
4,683,257 7/1987 Kakiuchi et al. 524/908
4,735,980 4/1988 Sturm et al. 524/392
4,770,422 9/1988 Isaac 524/708

Primary Examiner—Kriellion S. Morgan*Attorney, Agent, or Firm*—Sughrue, Mion, Zinn,
Macpeak & Seas[57] **ABSTRACT**

One-piece and multi-layered golf balls are improved in flying performance by forming the one-piece ball entirely or multi-layered golf ball core from a rubber composition comprising a base rubber, an unsaturated carboxylic acid metal salt, and an organic sulfur compound and/or a metal salt thereof.

13 Claims, 1 Drawing Sheet

U.S. Patent

Oct. 12, 1993

5,252,652

FIG. 1

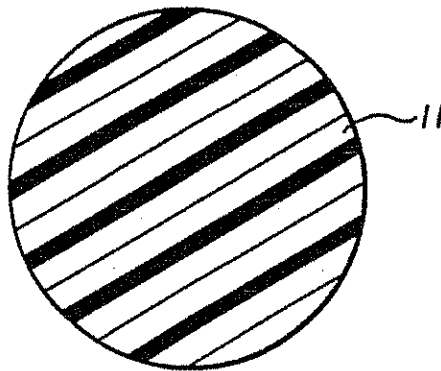
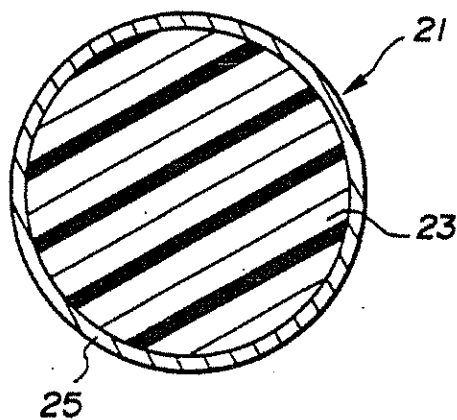


FIG. 2



5,252,652

1

SOLID GOLF BALL

This invention relates to solid golf balls having improved flying performance.

BACKGROUND OF THE INVENTION

In general, solid golf balls include a one-piece golf ball which is integrally molded in its entirety a two-piece golf ball having a core enclosed in a cover, and a multi-layered golf ball having a core enclosed in a cover through one or more intermediate layers.

These solid golf balls have an elastic portion in the form of a molded and vulcanized rubber compound as a portion, that is, a core in the case of multi-layered golf balls or as their entirety in the case of one-piece golf balls. For the purpose of improving the repulsion coefficient and impact resistance of the prior art rubber compositions from which the elastic portion was formed, attempts were made to blend a monomer having an unsaturated bond, typically an α,β -ethylenically unsaturated carboxylic acid metal salt as a co-crosslinking agent in polybutadiene or a similar base rubber. The co-crosslinking agent will graft or crosslink to the backbone of polybutadiene rubber under the action of a peroxide or similar co crosslinking initiator, resulting in a three-dimensional crosslinked polymer, which can provide an adequate degree of hardness and durability for one-piece golf balls or multi-layered golf ball cores. Therefore, one-piece golf balls formed from rubber compositions having such a co-crosslinking agent blended and multi-layered golf balls having cores formed from rubber compositions having such a co-crosslinking agent blended are known to exhibit satisfactory flying performance and durability.

Golf players have a continuous demand for better flying performance and it is thus desired to develop golf balls having further improved flying performance.

SUMMARY OF THE INVENTION

Therefore, an object of the invention is to provide a golf ball having further improved flying performance.

Searching for an optimum additive for a rubber composition containing a base rubber, typically polybutadiene and an unsaturated carboxylic acid metal salt as a co-crosslinking agent, the inventors have found that when an organic sulfur compound and/or a metal-containing organic sulfur compound is added to the rubber composition, there is obtained a rubber composition which can be vulcanized into a rubbery elastomer having improved rebound resilience. If a one piece golf ball or a multi-layered golf ball core is formed from this rubber composition, the resulting solid golf ball exhibits an increased initial velocity upon hitting and improved flying performance. The present invention is predicated on this finding.

According to the present invention, there is provided a solid golf ball comprising a rubber composition containing a base rubber, an unsaturated carboxylic acid metal salt, and a sulfur compound selected from the group consisting of an organic sulfur compound and a metal-containing organic sulfur compound.

In one form, the ball is a one-piece golf ball which is entirely formed of the present rubber composition.

In another form, the ball is a multi-layered golf ball comprising a core and a cover enclosing the core, wherein the core is formed of the present rubber com-

2

position. The core may be enclosed in the cover directly or through an intermediate layer.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross section of a one-piece golf ball.
FIG. 2 is a cross section of a two-piece golf ball.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 shows in cross section a one-piece golf ball 11. FIG. 2 shows a two-piece golf ball 21 comprising a core 23 coated with a cover 25. A plurality of, usually 200 to 600, dimples are formed on the surface of the golf balls, although they are not shown in FIGS. 1 and 2.

The solid golf ball of the present invention is a one piece golf ball or a multi-layered golf ball in which the one-piece golf ball or the core of the multi-layered golf ball is formed from a rubber composition comprising a base rubber, an unsaturated carboxylic acid metal salt, and an organic sulfur compound and/or a metal-containing organic sulfur compound.

The base rubber used herein may be any desired rubber which is commonly used in conventional one-piece golf balls and cores of multi-layered golf balls. Polybutadiene rubbers, especially poly(1,4-butadiene) rubbers containing at least 40 mol %, preferably 80 to 100 mol % of cis-1,4 bond are preferred because of high rebound resilience, extrusion moldability, and high strength after vulcanization. If desired, the poly(1,4-butadiene) rubbers may be blended with natural rubber, polyisoprene rubber, styrene-butadiene rubber or the like. It is desired that at least 80% by weight of poly(1,4-butadiene) rubber be present in the base rubber because base rubbers containing less amounts of poly(1,4-butadiene) rubber often fail to take advantage of the rebound resilience of polybutadiene rubber.

The metal salt of unsaturated carboxylic acid is blended as a co-crosslinking agent. Examples include zinc and magnesium salts of unsaturated fatty acids having 3 to 8 carbon atoms, such as acrylic acid, methacrylic acid, maleic acid, and fumaric acid, with the zinc salts of acrylic and methacrylic acid being most preferred. The unsaturated carboxylic acid metal salt may be blended in a rubber either as a preformed metal salt or by introducing an α,β -unsaturated carboxylic acid and a metal oxide or hydroxide into the rubber composition and allowing them to react in the rubber composition to form a metal salt. The unsaturated carboxylic acid metal salt may be blended in any desired amount, but preferably in amounts of about 25 to about 40 parts by weight per 100 parts by weight of the base rubber.

The rubber composition used in the manufacture of the solid golf ball of the invention contains an organic sulfur compound and/or a metal-containing organic sulfur compound in addition to the base rubber and the unsaturated carboxylic acid metal salt. Examples of the organic sulfur compound include thiophenols such as pentachlorothiophenol, 4-butyl-o-thiocresol, 4 t-butyl-p-thiocresol, and 2-benzamidothiophenol, thiocarboxylic acids such as thio-benzoic acid, and sulfides such as dixylyl disulfide, di(o-benzamidophenyl) disulfide and alkylated phenol sulfides. Examples of the metal-containing organic sulfur compound include zinc salts of the above-mentioned thiophenols and thiocarboxylic acids. The sulfur compounds may be used alone or in admixture of two or more of them. The sulfur compound is preferably blended in amounts of from about 0.05 to about 2 parts by weight, more preferably from

5,252,652

3

about 0.1 to about 0.5 parts by weight per 100 parts by weight of the base rubber.

The rubber composition of the invention may further contain a co-crosslinking initiator. Preferred examples of the co-crosslinking initiator include organic peroxides, such as dicumyl peroxide, t-butylperoxybenzoate, di-t-butylperoxide, 1,1-bis(t-butylperoxy)-3,3,5-trimethyl-cyclohexane, n-butyl-4,4-bis(t-butylperoxy)valerate, 2,2-bis(t-butylperoxy-isopropyl)benzene, and 2,5-dimethyl-2,5-di(t-butylperoxy)hexene, with the dicumyl peroxide being most preferred. The initiator may be blended in amounts of about 0.5 to about 3 parts by weight, preferably about 1 to about 2.5 parts by weight per 100 parts by weight of the base rubber.

Also employable is a filler. Preferred examples of the filler include metal oxides such as zinc oxide and magnesium oxide. It may be blended in amounts of about 10 to about 80 parts by weight per 100 parts by weight of the base rubber. If desired, the rubber composition can additionally contain a plasticizer, an antioxidant, and any other additives which are generally employed in the preparation of one-piece balls or cores of multi-layered balls. Their amounts may be determined without undue experimentation.

The solid golf ball of the invention may be prepared by molding the above-formulated rubber composition as formulated above into a desired spherical shape, that is, a ball in the case of a one-piece ball or into a core in the case of a multi-layered ball and vulcanizing the rubber by heating. The manufacture may be in accord with conventional method and conditions.

When multi-layered golf balls such as two-piece balls are manufactured, the core is coated with a cover. The cover material used herein may be selected from commonly used cover materials, for example, ionomers such as Surlyn®, polyesters, and nylons. The cover usually has a thickness of 0.5 to 2.5 mm.

The core may be enclosed in the cover directly or through an intermediate layer.

The present invention may be applied to any type of golf ball including small balls having a diameter of at least 41.15 mm and a weight of up to 45.92 g, and large balls having a diameter of at least 42.67 mm and a weight of up to 45.92 g.

The distribution and total number of dimples are not critical although 300 to 550 dimples, preferably 350 to 540 dimples are generally formed on a ball. Preferred dimple arrangements are regular icosahedral, regular dodecahedral, and regular octahedral arrangements. The dimples is preferably distributed uniformly on the ball surface in such an arrangement.

The solid golf balls of the invention are of the above-mentioned construction and exhibit excellent flying performance.

EXAMPLE

Examples of the invention are given below together with comparative examples by way of illustration and not by way of limitation.

EXAMPLES 1-6

Solid cores for two-piece golf balls were prepared and compared with conventional two-piece golf ball cores.

Six rubber compositions were prepared by mixing the ingredients shown in Table 1. A two-piece golf ball-forming solid core having a diameter of 38.0 mm was prepared by molding each of the compositions in a mold

4

followed by vulcanization at 155° C. for 20 minutes. The cores were examined by a hitting test according to the USGA standard. Using a hitting machine of the flywheel type, the cores were hit at a head speed of 38 m/sec. to measure the initial velocity (in m/sec.). The results are shown in Table 1.

TABLE 1

	Core No.					
	1	2	3	4*	5*	6*
<u>Ingredients (pbw)</u>						
Poly(cis-1,4-butadiene)	100	90	80	100	90	80
Poly(cis-isoprene)	0	10	20	0	10	20
Zinc acrylate	32	32	32	32	32	32
Zinc oxide	21	21	21	21	21	21
Antioxidant	0.2	0.2	0.2	0.2	0.2	0.2
Dicumyl peroxide	1.5	1.5	1.5	1.5	1.5	1.5
Pentachlorothiophenol	0.2	0.2	0.2	0	0	0
zinc salt						
Initial velocity, m/sec.	73.32	73.11	72.80	72.95	72.67	72.30

*outside the scope of the invention

As seen from Table 1, the performance, that is, initial velocity upon hitting of the core is improved by blending zinc salt of pentachlorothiophenol which is a metal salt of an organic sulfur compound in a rubber composition.

Examples 7 and 8

Two rubber compositions were prepared by blending the ingredients shown in Table 2. Two-piece golf ball solid cores having a diameter of 38 mm were prepared by molding the composition in a mold and vulcanizing at 155° C. for 20 minutes. An ionomer resin composition was applied to the cores to form a cover thereon. There were obtained two-piece golf balls having a diameter of 42.7 mm.

The balls were measured for weight, hardness and initial velocity. The hardness of the balls was measured as a deflection (in mm) under a load of 100 kg. The initial velocity (in m/sec.) of the balls was measured by a hitting test according to the USGA standard in which the balls were hit at a head speed of 38 m/sec. using a hitting machine of the flywheel type. The results are shown in Table 2.

TABLE 2

	Example	
	7	8*
<u>Core composition (pbw)</u>		
Poly(cis-1,4-butadiene) rubber	100	100
Zinc acrylate	32	32
Zinc oxide	21	21
Antioxidant	0.2	0.2
Dicumyl peroxide	1.5	1.5
Pentachlorothiophenol zinc salt	0.2	—
<u>Ball properties</u>		
Weight, g	45.3	45.3
Hardness	2.30	2.32
Initial velocity, m/sec.	73.37	72.84

*outside the scope of the invention

As seen from Table 1, the golf balls of the invention are improved in initial velocity upon hitting and hence, in flying performance.

Although some preferred embodiments have been described, many modifications and variations may be made thereto in the light of the above teachings. It is therefore to be understood that within the scope of the

5

5,252,652

6

appended claims, the invention may be practices otherwise than as specifically described.

We claim:

1. A solid golf ball, having an improved rebound property and initial velocity, comprising a rubber composition containing 100 parts by weight of a base rubber selected from the group consisting of polybutadiene rubber, natural rubber, polyisoprene rubber and styrene-butadiene rubber, about 25 to about 40 parts by weight of a zinc or magnesium salt of an unsaturated fatty acid having 3 to 8 carbon atoms, about 0.05 to about 2 parts by weight of a sulfur compound selected from the group consisting of pentachlorothiophenol, 4-t-butyl-o-thiocresol, 4-t-butyl-p-thiocresol, 2-benzamidothiophenol, thiobenzoic acid, and zinc salts thereof, and about 0.5 to about 3 parts by weight of an organic peroxide.

2. The solid golf ball of claim 1, wherein said solid golf ball is a one-piece golf ball which is formed of said rubber composition.

3. The solid golf ball of claim 1, wherein said solid golf ball core and a cover enclosing the core, and said core is formed of said rubber composition.

4. The solid golf ball of claim 3, wherein said solid golf ball is a two-piece ball, and said core is directly enclosed in the cover.

5. The solid golf ball of claim 3, wherein said solid golf ball further comprises an intermediate layer between the core and the cover.

6. The solid golf ball of claim 1, wherein said base rubber is a polybutadiene rubber.

7. The solid golf ball of claim 6, wherein said polybutadiene rubber is a poly(1,4-butadiene) rubber containing at least 40 mol % of cis-1,4 bond.

8. The solid golf ball of claim 7, wherein said poly(1,4-butadiene) rubber contains at least 80 to 100 mol % of cis-1,4 bond.

9. The solid golf ball of claim 7, wherein said base rubber comprises at least 80% by weight of said poly(1,4-butadiene) rubber.

10. The solid golf ball of claim 9, wherein said poly(1,4-butadiene) rubber is blended with a natural rubber, a polyisoprene rubber of a styrene-butadiene rubber.

11. The solid golf ball of claim 1, wherein said sulfur compound is blended in an amount of from about 0.1 to about 0.5 parts by weight.

12. The solid golf ball of claim 1, wherein said organic peroxide is selected from the group consisting of dicumyl peroxide, t-butylperoxybenzoate, di-t-butylperoxide, 1,1-bis(t-butylperoxy)-3,3,5-trimethylcyclohexane, n-butyl-4,4-bis(t-butylperoxy)valerate, 2,2'-bis(t-butylperoxyisopropyl)benzene, and 2,5-dimethyl-2,5-di(t-butylperoxy)hexene.

13. The solid golf ball of claim 1, wherein said rubber composition further comprises a filler.

* * * * *

35

40

45

50

55

60

65

:

EXHIBIT 20

United States Patent [19]

Tominaga et al.

[11] Patent Number: 4,556,220

[45] Date of Patent: Dec. 3, 1985

[54] SOLID GOLF BALLS

[75] Inventors: Ichiro Tominaga, Kobe; Akihiro
Nakahara, Ibaraki, both of Japan[73] Assignee: Sumitomo Rubber Industries, Ltd.,
Hyogo, Japan

[21] Appl. No.: 618,448

[22] Filed: Jun. 7, 1984

[30] Foreign Application Priority Data

Jun. 10, 1983	[JP]	Japan	58-104667
Jun. 10, 1983	[JP]	Japan	58-104668
Jun. 10, 1983	[JP]	Japan	58-104669

[51] Int. Cl.⁴ A63B 37/00; A63B 37/06[52] U.S. CL 273/218; 260/998.14;
524/83; 524/84; 524/908; 525/244; 525/256;
525/259; 525/261; 525/327.5[58] Field of Search 524/908, 83, 84;
273/218; 525/244, 256, 259, 261, 327.5;
260/998.14

[56] References Cited

U.S. PATENT DOCUMENTS

3,384,612	5/1968	Brandt et al.	524/908
3,992,014	11/1976	Retford	524/908
4,165,877	8/1979	Miller et al.	273/218
4,266,772	5/1981	Martin et al.	273/218

FOREIGN PATENT DOCUMENTS

707231	4/1965	Canada	524/908
57-25337	2/1982	Japan	273/218
57-78875	5/1982	Japan	273/218
1448451	9/1976	United Kingdom	273/218

Primary Examiner—Allan M. Lieberman

Attorney, Agent, or Firm—Birch, Stewart, Kolasch &
Birch

[57] ABSTRACT

The present invention provides solid golf balls having excellent rebound performance, durability and flight carry characteristics produced from a rubber composition containing one or more agents for regulating the molecular weight of grafted chain selected from the group consisting of 2-(4-morpholinylidithio) benzothiazole, 4,4'-dithio-bis-dimorpholine, dipentamethylenethiuram tetrasulfide and derivatives thereof.

5 Claims, No Drawings

1

SOLID GOLF BALLS

BACKGROUND OF THE INVENTION

A solid golf ball includes one-piece golf balls comprising one constituent, two-piece golf balls comprising a solid core and a cover covering the former, and multi-layer golf balls having one or more suitable intermediate layers between the solid core and the cover. Of these solid golf balls, there are known those in which a monomer having an unsaturated bond, for example, the metallic salt of an α,β -monoethylenic unsaturated carboxylic acid, has been incorporated as a co-crosslinking agent in order to improve both rebound coefficient and impact resistance. These solid golf balls themselves have fairly superior performances, but golf balls having more superior rebound coefficient and durability are required.

Hitherto, the moderate hardnesses (compression; compression ratio) and durability of said golf balls, as produced from the composition containing a monomer such as the metallic salt of an α,β -ethylenic unsaturated carboxylic acid, have been considered to result from the fact that the monomer is grafted to the polybutadiene main chain by the action of a free radical initiator, thereby acting as a co-crosslinking agent. But, when the grafted chain produced in this co-crosslinking becomes too long, a reduction in the rebound performance of the golf ball is brought about in the same manner as in blending a polybutadiene rubber with other polymers.

The present inventors tried to give a moderate hardness and durability to solid golf balls and at the same time remarkably improve their rebound performance by regulating the length of the grafted chain produced in co-crosslinking of the foregoing α,β -ethylenic unsaturated carboxylic acid, and as a result, found that one group of polysulfide type compounds has a very superior performance as an agent for regulating the molecular weight of the grafted chain. The present inventors thus completed the present invention.

SUMMARY OF THE INVENTION

The present invention provides solid golf balls produced from a rubber composition containing one or more agents for regulating the molecular weight of grafted chain selected from the group consisting of 2-(4-morpholinyl)dithio)benzothiazole, 4,4'-dithio-bisdimorpholine, dipentamethylenethiuram tetrasulfide and derivatives thereof.

DETAILED EXPLANATION OF THE INVENTION

The α,β -monoethylenic unsaturated carboxylic acid used in the present invention, as described for example in Japanese Patent Publication No. 19615/1980, is acrylic acid, methacrylic acid, etc., and methacrylic

4,556,220

2

acid is particularly preferred. Of course, acrylic acid and methacrylic acid may be used in combination. The metallic salt of the foregoing α,β -monoethylenic unsaturated carboxylic acid is the salt of a divalent metal, for example the zinc salt, calcium salt, magnesium salt, zirconium salt, etc., and the zinc salt is particularly preferred.

The amount of the foregoing agent for regulating the molecular weight of grafted chain used is about 0.1 to about 10 parts by weight, particularly preferably 0.1 to 5 parts by weight based on 100 parts by weight of the rubber component. When said amount is less than 0.1 part by weight, the effect of addition is not sufficiently displayed.

As the rubber component used in practicing the present invention, polybutadiene is used alone or in combination with a natural rubber, synthetic polyisoprene rubber or the like of not more than about 10 percents by weight based on the rubber component. When the amount of the natural rubber or synthetic polyisoprene rubber blended is more than 10 percents by weight, the rebound coefficient of the ball obtained markedly lowers.

To the composition for the solid golf ball of the present invention, proper amounts of a free radical initiator for polymerizing the α,β -ethylenic unsaturated carboxylic acid (e.g. dicumyl peroxide), an antioxidant, a filler (e.g. zinc oxide) and the like are added.

The solid golf ball obtained in the present invention may be any of one-piece golf balls, two-piece ones and multi-layer ones as described above. In either case, the golf balls obtained show markedly superior rebound performance, durability and flight carry characteristics as compared with those obtained with the monomer alone such as the metallic salt of the α,β -ethylenic unsaturated carboxylic acid.

Next, the present invention will be illustrated with reference to the following examples.

EXAMPLES 1 TO 3 AND COMPARATIVE EXAMPLES 1 TO 4

The materials shown in Table 1 were kneaded on a kneading roll and pressure-molded at about 149° C. for 30 minutes into a solid core (diameter, 39 mm). The physical properties of the core obtained are shown in Table 1.

Separately from this, a blend of 100 parts by weight of an ionomer resin (Surlyn 1601; produced by Du Pont Co.) and 5 parts by weight of titanium dioxide was molded into a cover of semi-spherical shell form.

The solid core above was then wrapped with two pieces of the semi-spherical cover and pressure-molded into a two-piece golf ball having a diameter of about 41.2 mm. The flight carry of the solid golf ball obtained was measured by means of a driver (45.0 m/sec), and the result is shown in Table 1.

TABLE 1

		Example			Comparative example			
		1	2	3	1	2	3	4
Material of core	Cis 1,4-polybutadiene ⁽¹⁾	100	100	100	100	100	100	100
	Zinc acrylate	35	40	43	30	35	40	40
	Zinc oxide	53.1	52.7	52.3	54.5	53.7	52.8	52.7
	Antioxidant ⁽²⁾	0.5	0.5	0.5	0.5	1.2	1.8	0.5
	Dicumyl peroxide	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	2-(4-morpholinyl)dithio)benzothiazole	0.5	0.7	0.9	—	—	—	—
	Sulfur	—	—	—	—	—	—	0.7
Physical	Weight (g)	35.30	35.29	35.28	35.32	35.32	35.30	35.20

3

4,556,220

4

TABLE 1-continued

		Example			Comparative example			
		1	2	3	1	2	3	4
property	Compression ⁽³⁾	48	50	52	51	50	50	128
of core	Rebound coefficient index ⁽⁴⁾	109	115	118	102	100	94	—
	Durability index ⁽⁵⁾	102	105	109	100	100	106	—
Flight carry of two-piece solid golf ball (m)		209	210	213	207	206	204	—

⁽¹⁾BR-01; produced by Japan Synthetic Rubber Co., Ltd.⁽²⁾2,2'-methylene bis(4-methyl-6-tert-butylphenol); produced by American Cyanamid Co., available as Antioxidant 2246.⁽³⁾The value, as expressed in 1/100 inch, of the amount of strain obtained when a definite load was applied after giving a definite initial strain.⁽⁴⁾The relative value of rebound coefficient with the rebound coefficient of the core obtained in Comparative example 2 as 100.⁽⁵⁾The relative value of impact resistance, as expressed by the number of applied impacts, with the impact resistance of the core obtained in Comparative Example 1 as 100.EXAMPLES 4 TO 6 AND COMPARATIVE
EXAMPLES 5 TO 8

The materials shown in Table 2 were kneaded on a kneading roll and pressure-molded at about 149° C. for 30 minutes into a solid core (diameter, 39 mm). The physical properties of the core obtained are shown in Table 2.

Separately from this, a blend of 100 parts by weight of an ionomer resin (Surlyn 1601; produced by Du Pont Co.) and 5 parts by weight of titanium dioxide was molded into a cover of semi-spherical shell form.

The solid core above was then wrapped with two pieces of the semi-spherical cover and pressure-molded into a two-piece golf ball having a diameter of about 41.2 mm. The flight carry of the solid golf ball obtained was measured by means of a driver (45.0 m/sec), and the result is shown in Table 2.

EXAMPLE 7 TO 9 AND COMPARATIVE
EXAMPLES 9 TO 12

The materials shown in Table 3 were kneaded on a kneading roll and pressure-molded at about 149° C. for 30 minutes into a solid core (diameter, 39 mm). The physical properties of the core obtained are shown in Table 3.

Separately from this, a blend of 100 parts by weight of an ionomer resin (Surlyn 1601; produced by du Pont Co.) and 5 parts by weight of titanium dioxide was molded into a cover of semi-spherical shell form.

The solid core above was then wrapped with two pieces of the semi-spherical cover and pressure-molded into a two-piece golf ball having a diameter of about 41.2 mm. The flight carry of the solid golf ball obtained was measured by means of a driver (45.0 m/sec), and the result is shown in Table 3.

TABLE 2

		Example			Comparative example			
		4	5	6	5	6	7	8
Material	Cis 1,4-polybutadiene ⁽¹⁾	100	100	100	100	100	100	100
of core	Zinc acrylate	35	40	43	30	35	40	40
	Zinc oxide	53.2	52.8	52.4	54.5	53.7	52.8	52.7
	Antioxidant ⁽²⁾	0.5	0.5	0.5	0.5	1.2	1.8	0.5
	Dicumyl peroxide	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	4,4'-dithio-bis-dimorpholine	0.4	0.7	1.0	—	—	—	—
	Sulfur	—	—	—	—	—	—	0.7
Physical	Weight (g)	35.32	35.31	35.30	35.32	35.32	35.30	35.21
property	Compression ⁽³⁾	50	50	51	51	50	50	130
of core	Rebound coefficient index ⁽⁴⁾	110	117	120	102	100	94	—
	Durability index ⁽⁵⁾	101	104	108	100	102	105	—
Flight carry of two-piece solid golf ball (m)		210	211	215	207	206	204	—

⁽¹⁾BR-01; produced by Japan Synthetic Rubber Co., Ltd.⁽²⁾2,2'-methylene bis(4-methyl-6-tert-butylphenol); produced by American Cyanamid Co., available as Antioxidant 2246.⁽³⁾The value, as expressed in 1/100 inch, of the amount of strain obtained when a definite load was applied after giving a definite initial strain.⁽⁴⁾The relative value of rebound coefficient with the rebound coefficient of the core obtained in Comparative example 6 as 100.⁽⁵⁾The relative value of impact resistance, as expressed by the number of applied impacts, with the impact resistance of the core obtained in Comparative Example 5 as 100.

TABLE 3

		Example			Comparative example			
		7	8	9	9	10	11	12
Material	Cis 1,4-polybutadiene ⁽¹⁾	100	100	100	100	100	100	100
of core	Zinc acrylate	35	40	43	30	35	40	40
	Zinc oxide	53.1	52.7	52.2	54.5	53.7	52.8	52.7
	Antioxidant ⁽²⁾	0.5	0.5	0.5	0.5	1.2	1.8	0.5
	Dicumyl peroxide	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	Dipentamethylenethiuram tetrasulfide	0.4	0.6	1.0	—	—	—	—
	Sulfur	—	—	—	—	—	—	0.6
Physical	Weight (g)	35.30	35.33	35.35	35.32	35.33	35.30	35.30
property	Compression ⁽³⁾	49	50	51	50.7	50.0	50.0	120
of core	Rebound coefficient index ⁽⁴⁾	110	112	117	102	100	94	70
	Durability index ⁽⁵⁾	102	105	106	100	100	106	—

5

4,556,220

6

TABLE 3-continued

	Example			Comparative example			
	7	8	9	9	10	11	12
Flight carry of two-piece solid golf ball (m)	209	211	214	206	205	203	—

(1)BR-01; produced by Japan Synthetic Rubber Co., Ltd.

(2)2,2'-methylene bis(4-methyl-6-tert-butylphenol); produced by American Cyanamid Co., available as Antioxidant 2246.

(3)The value, as expressed in 1/100 inch, of the amount of strain obtained when a definite load was applied after giving a definite initial strain.

(4)The relative value of rebound coefficient with the rebound coefficient of the core obtained in Comparative example 10 as 100.

(5)The relative value of impact resistance, as expressed by the number of applied impacts, with the impact resistance of the core obtained in Comparative Example 9 as 100.

What is claimed is:

1. A solid golf ball comprising a rubber component selected from the group consisting of polybutadiene and polybutadiene with up to 10% of synthetic or natural polyisoprene, an α,β -monoethylenic unsaturated carboxylic acid salt of a divalent metal grafted thereto, and at least one molecular weight regulating agent selected from the group consisting of 2-(4-morpholinylthio)benzothiazole, 4,4'-dithio-bis-dimorpholine, dipentamethylenethiuram tetrasulfide and derivatives thereof, said regulating agent being present in an amount of about 0.1 to about 10 parts by weight based on 100 parts by weight of the rubber component.

2. The solid golf ball as described in claim 1, wherein said rubber composition contains more than 90 percents by weight of a polybutadiene rubber based on the rubber component.

3. The solid golf ball of claim 1 wherein the α,β -monoethylenic unsaturated carboxylic acid is selected from the group consisting of acrylic acid, methacrylic acid and mixtures thereof.

4. The solid golf ball of claim 1 wherein the divalent metal is selected from the group consisting of zinc salt, calcium salt, magnesium salt, and zirconium salt.

5. The solid golf ball of claim 1 wherein the requesting agent is used in an amount of about 0.1 to 5 parts by weight based on 100 parts by weight of the rubber component.

* * * * *

30

35

40

45

50

55

60

65